

CONTRIBUTIONS

FROM THE

CUSHMAN LABORATORY

FOR

FORAMINIFERAL RESEARCH

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Laboratory for Foraminiferal
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Contributions

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CONTRIBUTIONS FROM THE CUSHMAN LABORATORY FOR FORAMINIFERAL RESEARCH

VOLUME 1, PART 1, APRIL 1925

1. A NEW CRETACEOUS UVIGERINA FROM LOUISIANA

By JOSEPH A. CUSHMAN

Chapman in his work on the Foraminifera published in 1902 gives the geologic range of the genus *Uvigerina* as "Eocene to Recent." There are a few records for the Cretaceous and some even earlier, but the main development of the genus is in the Tertiary. No species of the genus has been recorded from the Cretaceous of America. Mr. A. L. Selig has sent me some specimens of *Uvigerina* obtained from a core taken from basal Arkadelphia Clay at a depth of 1610-1612 feet in a well of the Atlantic Oil Prod. Co., Johnson No. 1, in Bossier Parish, Louisiana. There are a number of specimens which have proved to belong to a new species.

UVIGERINA SELIGI Cushman, n. sp.

Plate 4, figs. 1 a-c

Test minute, less than twice as long as broad; chambers comparatively few, the last three making up the larger part of the test, in end view somewhat angled, basal part of each chamber cut under sharply leaving a somewhat overhanging shoulder; sutures very distinct, depressed; surface minutely roughened, with a few prominent longitudinal costae, those of each chamber independent of adjacent ones; aperture circular with a short, broad, cylindrical neck and slight phialine lip.

Length 0.25 mm.; breadth 0.15 mm.

Type specimens from Upper Cretaceous Arkadelphia Clay, at a depth of 1610-1612 feet in Bossier Parish, Louisiana.

This species resembles slightly the forms found in the Eocene and Oligocene of the Coastal Plain of the United States and Mexico in its small size and angular chambers, and may well be the ancestral form of those species.

2. THREE NEW SPECIES OF SIPHOGENERINA FROM THE MIOCENE OF CALIFORNIA

By JOSEPH A. CUSHMAN

In 1905, Dr. R. M. Bagg, Jr. (Bulletin 268, U. S. Geol. Survey) described and figured some *Siphogenerinas* under the names *Sagrina branneri*, *S. californiensis*, and *S. elongata* Bagg. These were from the Monterey shale of Graves Creek, San Luis Obispo Co., California. It is probable that the latter two names are synonyms of *Siphogenerina branneri* Bagg, this being the microspheric form and the other two the megalospheric form of one species. I have some of the original material collected by Doctor Branner which seems to confirm this.

The Monterey has in it other species of *Siphogenerina* which are very different from those described and figured by Bagg. Of these three are here described and figured:

SIPHOGENERINA COLLOMI Cushman, new species

Plate 4, figure 3

Test large for the genus, fusiform, greatest width above the middle; early chambers irregularly spiral, later ones uniserial, distinct; sutures depressed, strongly curved, extending back on the costae to a considerable distance; test ornamented with very high, plate-like costae, usually ten in number, last-formed chamber smooth; aperture with a very short cylindrical neck and phialine lip.

Length up to 1.60 mm.; breadth 0.65 mm.

Type specimen (Cushman Coll. No. 4325) from Monterey shale, Sect. 24, T.28S., R.14E., San Luis Obispo County, California, collected by W. D. Kleinpell.

This species is nearest related to *Siphogenerina spinosa* Bagg from the Miocene of Maryland and *S. lamellata* Cushman from the Miocene of Florida. The species is named for Roy E. Collom, well known geologist of California.

SIPHOGENERINA REEDI Cushman, new species

Plate 4, figure 4

Test about twice as long as broad, greatest breadth at the apertural end, thence gradually tapering to the initial end; chambers distinct; sutures somewhat depressed, strongly curved; wall ornamented with about fifteen lamellate costae which may continue onto the last-formed chamber; apertural characters obscure.

Length up to 1.10 mm.; breadth 0.50 mm.

Type specimen (Cushman Coll. No. 4326) from Monterey shale, Sect. 24, T.28S., R.14E., San Luis Obispo County, California, collected by W. D. Kleinpell.

This may be distinguished from *S. collomi* by its smaller size and greater number of costae. It is nearest the form I have described from the Panama Canal Zone as *S. raphanus* (Parker and Jones), var. *transversus* Cushman.

It is named for Ralph D. Reed, geologist of California, under whose direction the material was collected.

SIPHOGENERINA KLEINPELLI Cushman, new species

Plate 4, figure 5

Test about twice as long as broad, greatest breadth at the apertural end, thence irregularly tapering to the initial end; chambers distinct; sutures depressed, very slightly if at all curved; wall ornamented with about fifteen very low costae, not at all lamellate, not continuing onto the last-formed chamber; aperture with a very short cylindrical neck and slight phialine lip.

Length up to 1 mm.; breadth 0.50 mm.

Type specimen (Cushman Coll. No. 4327) from Monterey shale, Sect. 24, T.28S., R.14E., San Luis Obispo County, California, collected by W. D. Kleinpell.

This species may be distinguished from *S. reedi* by the much lower and less prominent costae, and the lack of curvature in the sutures.

It is named for W. D. Kleinpell who collected the material.

3. NEW FORAMINIFERA FROM THE UPPER EOCENE OF MEXICO

By JOSEPH A. CUSHMAN

Plate 1

From material received from the Marland Oil Company of Mexico collected south and southeast of the Panuco River, there were obtained a number of new species representing both the Alazan and the Tantoyuca formations. A number of these are new to science, and are described and figured here. The Alazan species occur with *Hantkenina alabamensis* Cushman and the Tantoyuca species with *Hantkenina brevispina* Cushman. Most of these species are confined, so far as is known, to the Mexican Upper Eocene, but one of them at least, *Bulimina jacksonensis* Cushman, n. sp., is common throughout the Coastal Plain Upper Eocene of the United States. Descriptions of the new species follow:

Genus ROTALIATINA Cushman, n. gen.

Rotalina REUSS, (in part) Zeitschr. deutsch. geol. Ges., vol. 3, 1851, p. 77, (not *Rotalina* d'Orbigny).

Test free, trochoid, spiral, composed of about three volutions, the last one composed of numerous chambers, all the chambers exposed from the dorsal side, only those of the last-formed coil visible from the ventral side, umbilicate ventrally; chambers distinct; sutures distinct and usually slightly depressed; wall in the known species smooth; aperture an arched slit between the base of the apertural face and the previous coil. (Type of genus *Rotaliatina mexicana* Cushman, n. sp.)

ROTIATINA MEXICANA Cushman, n. sp.

Plate 1, figs. 1 a, b, c

Test about as broad as long, composed of two or more coils, the earlier coils projecting in a low, rounded spire on the dorsal side, whole test generally tumid; chambers distinct, about seven in the last-formed coil, all visible from the dorsal side, only those of the last-formed coil from the ventral side; sutures dis-

tinct but not depressed unless very slightly so on the ventral side; wall smooth, polished; aperture a rather high, arched slit in the central part of the line between the base of the apertural face of the last-formed chamber and the previous coil.

Length 0.55 mm.; diameter 0.45 mm.

Type specimen (Cushman Coll. No. 4329) from the Upper Eocene, Alazan shale, $2\frac{1}{3}$ km. S. W. of Carrizo on the Rio Tamuin, State of San Luis Potosi, Mexico.

PLEUROSATOMELLA ALAZANENSIS Cushman, n. sp.

Plate 1, figs. 2 *a*, *b*

Test elongate, fusiform, about three times as long as broad, initial end acute, apertural end broadly rounded; chambers few, ornamented, fairly distinct; sutures distinct but not depressed; wall smooth; apertural face of the last-formed chamber truncate, depressed, with a liplike projection above the aperture and below a notched plate.

Length 0.90 mm.

Type specimen (Cushman Coll. No. 4330) from the Upper Eocene, Alazan shale, $2\frac{1}{3}$ km. S. W. of Carrizo on the Rio Tamuin, State of San Luis Potosi, Mexico.

NODOSARIA MEXICANA Cushman, n. sp.

Plate 1, figs. 3, 4

Test elongate, tapering, slightly curved, initial end narrow, rounded; chambers of the early portion rounded or subcylindrical, later ones gradually developing a raised area about the central equatorial region, thence tapering toward either end; sutures distinct, slightly limbate; wall smooth; apertural end slightly produced, conical.

Length 1 mm. or slightly more.

Type specimen (Cushman Coll. No. 4331) from the Upper Eocene, Tantoyuca formation, yellow clay from Palacho Hacienda, S. of Panuco-Tampico R. R., State of Vera Cruz, Mexico.

UVIGERINA TOPILENSIS Cushman, n. sp.

Plate 1, figs. 5 *a*, *b*

Test generally fusiform, broadest in the middle, initial and apertural ends both rounded; chambers irregularly spiral, inflated; sutures distinct, depressed; wall ornamented with a very

few costae, progressively decreasing in height toward the apertural end of the test and usually continuous from one chamber to another, the last-formed chamber usually smooth; wall finely punctate, the costae on the earliest portion sometimes projecting backward into platelike processes; aperture with a very narrow cylindrical neck.

Length 0.70 mm.; breadth 0.30 mm.

Type specimen (Cushman Coll. No. 4332) from the Upper Eocene, Tantoyuca formation, yellow clay from Palacho Hacienda, S. of Panuco-Tampico R. R., State of Vera Cruz, Mexico.

BULIMINA JACKSONENSIS Cushman, n. sp.

Plate 1, figs. 6, 7

Test elongate, tapering, the initial end acute, broadly rounded at the apertural end and in adults somewhat contracted; chambers numerous, fairly distinct; sutures not depressed; surface ornamented by very prominent longitudinal costae, usually six to eight in number, platelike, much raised above the general surface, continuous from the apical end to the base of the last-formed chamber in adults; the outer margin in well-preserved specimens serrate; aperture elongate, comma-shaped.

Length 1 mm. or more.

Type specimen (Cushman Coll. No. 4333) from the Upper Eocene, Tantoyuca formation, yellow clay from Palacho Hacienda, S. of Panuco-Tampico R. R., State of Vera Cruz, Mexico.

GLOBIGERINA MEXICANA Cushman, n. sp.

Plate 1, figs. 8 *a*, *b*

Test subglobular, early chambers spirally arranged, in the later development the last-formed chamber making up nearly half the surface of the test; chambers distinct, inflated; sutures distinct, somewhat depressed; wall fairly thick, generally reticulate, surface dull; aperture at the inner margin of the chamber with additional small openings at its periphery.

Diameter 0.40—0.60 mm.

Type specimen (Cushman Coll. No. 4334) from the Upper Eocene, Tantoyuca formation, yellow clay from Palacho Hacienda, S. of Panuco-Tampico R. R., State of Vera Cruz, Mexico.

This species is nearest related to *Globigerina conglobata* H. B. Brady, but is more spherical, the chambers being very different in their arrangement, and the surface much more smooth than in that species.

GLOBIGERINA TOPILENSIS Cushman, n. sp.

Plate 1, figs. 9 *a-c*

Test irregular in form, generally plano-convex, the dorsal side nearly flat, ventral side much inflated, early chambers making a generally spherical test but the last three or four greatly expanded, each chamber being somewhat rectangular in transverse section, the outer face nearly flat; sutures in the last-formed coil very much depressed, whole test deeply umbilicate; wall very strongly reticulate; aperture opening onto the umbilical area.

Diameter 0.50 mm.; height 0.35 mm.

Type specimen (Cushman Coll. No. 4335) from the Upper Eocene, Tantoyuca formation, yellow clay from Palacho Hacienda, S. of Panuco-Tampico R. R., State of Vera Cruz, Mexico.

This is a very unusual form of this genus with its generally spherical early development, but very much changed shape in the adult. There are a number of specimens all showing this same character.

HANTKENINA BREVISPINA Cushman

Plate 1, fig. 10

Hantkenina brevispina CUSHMAN, Proc. U. S. Nat. Mus., vol. 66, 1924, p. 2, pl. 2, fig. 3.

The specimen here figured is from the Upper Eocene, Tantoyuca formation, yellow clay from Palacho Hacienda, S. of Panuco-Tampico R. R., State of Vera Cruz, Mexico.

HANTKENINA ALABAMENSIS Cushman

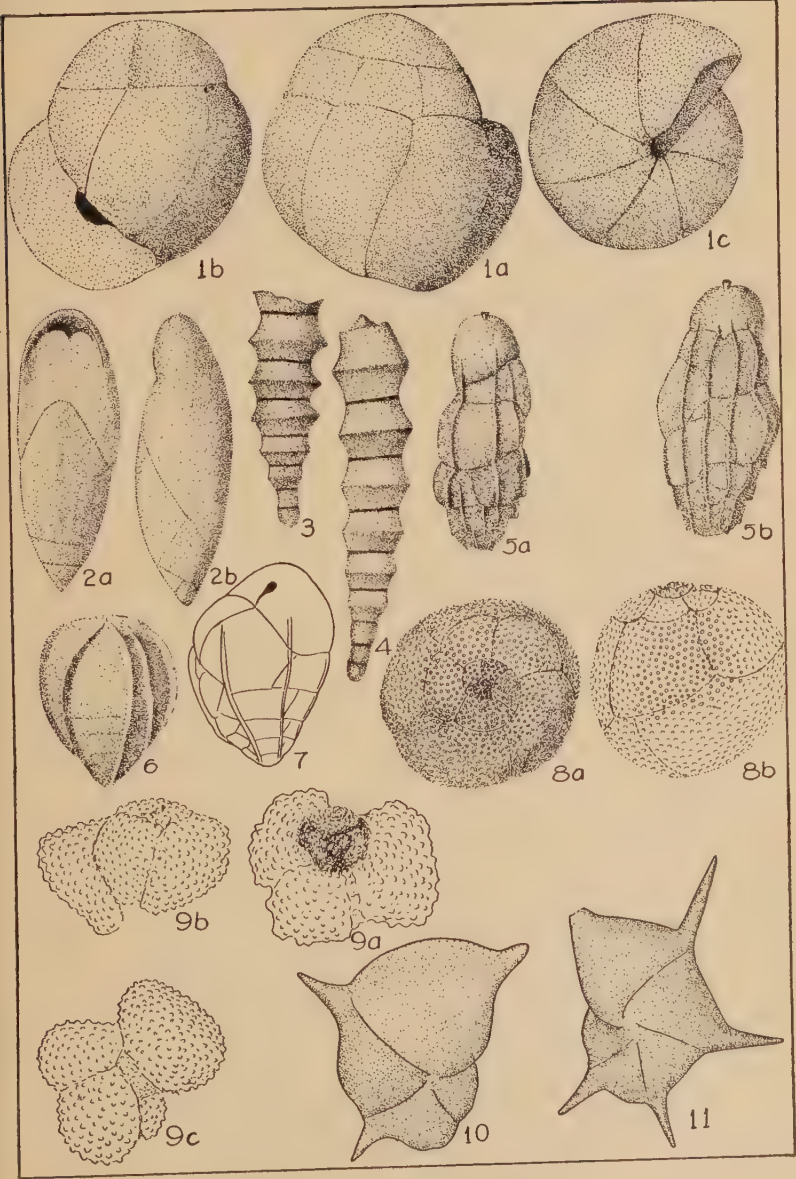
Plate 1, fig. 11

Hantkenina alabamensis CUSHMAN, Proc. U. S. Nat. Mus., vol. 66, 1924, p. 3, pl. 1, figs. 1-6; pl. 2, fig. 5.

The specimen here figured is from the Upper Eocene, Alazan shale, $2\frac{1}{3}$ km. S. W. of Carrizo on the Rio Tamuin, State of San Luis Potosi, Mexico.

EXPLANATION OF PLATE 1

- FIGS. 1 *a-c*. *Rotaliatina mexicana* Cushman, n. sp. X 65.
a, side view; *b*, apertural view; *c*, ventral view.
- FIGS. 2 *a, b*. *Pleurostomella alazanensis* Cushman, n. sp. X 40.
a, apertural view; *b*, side view.
- FIGS. 3, 4. *Nodosaria mexicana* Cushman, n. sp. X 40.
- FIGS. 5 *a, b*. *Uvigerina topilensis* Cushman, n. sp. X 45.
Side views.
- FIGS. 6, 7. *Bulimina jacksonensis* Cushman, n. sp. X 30.
Side views.
- FIGS. 8 *a, b*. *Globigerina mexicana* Cushman, n. sp. X 65.
a, dorsal view; *b*, side view.
- FIGS. 9 *a-c*. *Globigerina topilensis* Cushman, n. sp. X 65.
a, dorsal view; *b*, side view; *c*, ventral view.
- FIG. 10. *Hantkenina brevispina* Cushman. X 50.
- FIG. 11. *Hantkenina alabamensis* Cushman. X 50.



4. A NEW UVIGERINA FROM THE VIENNA BASIN

By JOSEPH A. CUSHMAN

Species of *Uvigerina* which are truly compressed are very rare. The only published species which shows this character strongly marked is *Uvigerina parkeri* Karrer (Abhandl. Geol. Reichsanstalt, vol. 9, 1877, p. 385, pl. 16b, fig. 5) from Wollersdorf in the Vienna Basin.

In some very excellent foraminiferal material from Perchtoldsdorf in the same Basin I have found another compressed species very different from *U. parkeri*.

UVIGERINA COMPRESSA Cushman, n. sp.

Plate 4, figs. 2 a-c

Test small, slender, elongate, about four times as long as broad, much compressed except in the earliest portion, periphery strongly lobulate; chambers numerous, very distinct, early ones irregularly spiral, later ones from compression tending to become biserial, the earlier end of each chamber strongly overlapping the preceding; sutures depressed, very distinct; surface ornamented throughout by numerous, very distinct but fine costae, in the very earliest chambers produced into short spines; aperture with a very slender, rather short, cylindrical neck and thin phialine lip.

Length 0.65 mm.; breadth 0.15 mm.; thickness 0.08 mm.

Type specimens (Cushman Coll. No. 4328) from "Mediterranean-stufe" of Perchtoldsdorf, near Vienna.

A comparison of this species with *Uvigerina parkeri* Karrer will show that the two are very distinct, *U. compressa* being a much more ornate species.

5. SOME LATER TERTIARY CASSIDULINAS OF CALIFORNIA

By JOSEPH A. CUSHMAN and DONALD D. HUGHES

Plate 2

A study of some of the later Tertiary Cassidulinas of California and a comparison of them with the original figures and descriptions, as well as a series of both recent and fossil specimens, have given interesting results.

The Pliocene Cassidulinas are very different from most other species of the genus in the literature. Dr. R. M. Bagg, Jr., who worked on some of the material, especially that from Timms Point, San Pedro, has referred the species of that formation to species which will be indicated in the synonymy. His figures, except in one case, were not from California material. In the Timms Point Pliocene which is rich in foraminifera, Cassidulinas form about three-quarters of the individuals present. Two species, *C. californica* Cushman and Hughes, n. sp., and *C. limbata* Cushman and Hughes, n. sp., are very abundant.

In the Pleistocene material collected from the Lomita Quarry on the north slope of the Palos Verdes Hills, the relative abundance of *Cassidulina* is much less than in the Pliocene of Timms Point, where it was the dominant genus. In the Lomita Quarry material *Globigerina* becomes the dominant genus. Of the Cassidulinas, which constitute about 5 per cent of the foraminifera of Lomita Quarry, *C. translucens* Cushman and Hughes, n. sp., occurs most abundantly.

In this California Tertiary material there seems to be nothing that can be definitely referred to *Cassidulina laevigata* d'Orbigny. The genotype, *C. laevigata* d'Orbigny, was described from ship's ballast, and therefore has no definite locality. It most resembles cold-water material from the North Atlantic.

Paratypes of the new species here described are deposited in the U. S. National Museum, Leland Stanford, Jr. University, the University of California, and the California Academy of Sciences.

CASSIDULINA CALIFORNICA Cushman and Hughes, n. sp.

Plate 2, figs. 1 a-c

Cassidulina subglobosa BAGG, Bull. 513, U. S. Geol. Surv., 1912, p. 44,
(not *C. subglobosa* H. B. Brady).

Test broadly oval in side view, nearly circular except for the last-formed chamber which slightly projects, periphery very slightly if at all lobulate, in apertural view with the sides parallel and the ends broadly rounded, the sides even tending to become slightly concave in the middle; chambers alternating, five pairs making up the last-formed coil, distinct; sutures very distinct, very slightly limbate but not raised, flush with the surface; wall smooth, matte; aperture in the general axis of the test at one side with a projecting platelike tooth, partially filling the actual opening.

Length 1 mm. or slightly more; thickness 0.50 mm.

Holotype (Cushman Coll. No. 4336) from the Pliocene of Timms Point, San Pedro, California. Specimens are very abundant in this material.

This is evidently the species referred to *Cassidulina subglobosa* by Bagg, as noted above. It differs much from that species in its parallel sides, the length being nearly twice the breadth, and the lack of inflation of the chambers, together with the position and shape of the aperture. It is much thicker than *C. crassa* d'Orbigny. In the young the specimens are more like *C. subglobosa*, and it was probably the young of *C. californica* that was referred by Bagg to *C. calabra*. Fewer specimens of *C. californica* were observed in the Lomita Quarry Pleistocene than in the Pliocene of San Pedro.

CASSIDULINA LIMBATA Cushman and Hughes, n. sp.

Plate 2, figs. 2 a-c

Cassidulina laevigata BAGG, Bull. 513, U. S. Geol. Surv., 1912, p. 43,
(not d'Orbigny).

Test nearly circular in side view, the last-formed chamber slightly projecting, periphery slightly lobulate, carinate; chambers very distinct, six pairs in the last-formed coil, the central portion of each chamber narrowest; sutures very distinct, broadly limbate, central portion with a distinct umbo of clear shell material; aperture narrow, elongate, parallel to the general axis of coiling.

Length 0.75 mm.; thickness 0.45 mm.

Holotype (Cushman Coll. No. 4337) from the Pliocene of Timms Point, San Pedro, California.

Next to *Cassidulina californica* this is the most common species in the Timms Point material. It was apparently referred by Baggs to *C. laevigata* d'Orbigny, but differs from that species in the larger number of chambers, the peculiar narrowing of the middle portion in each, the very distinctly limbate sutures, and prominent umbo. This is somewhat similar to the next species, *C. pulchella* d'Orbigny, but differs from it in the umbonate character and the very prominent limbate sutures, as well as the peculiar shape of the chambers.

There is a tendency in some specimens for the carina to be less developed and the sutures less limbate than in the typical form, but even in such specimens the "pinched-in" character of the middle portion of the chambers will distinguish the species.

In the Lomita Quarry material *Cassidulina limbata* is quite common, but does not develop the limbate character to such a marked extent as in the Pliocene, but the peculiar form of the chambers in this species serves at once to distinguish it.

CASSIDULINA PULCHELLA d'Orbigny

Plate 2, figs. 6 a, b

Cassidulina pulchella D'ORBIGNY, Voy. Amér. Mér., 1839, "Foraminifères," p. 57, pl. 8, figs. 1-3.

Test compressed, nearly circular in side view, last-formed chamber projecting, periphery slightly angled, in apertural view the sides nearly parallel; chambers distinct, six or seven pairs in the last-formed coil, rather broad and not greatly curved; sutures fairly distinct, slightly depressed, not limbate; surface smooth; aperture elongate at one side, and nearly parallel to the axis of coiling, the outer end of the aperture slightly broader than the inner end.

Length up to 0.75 mm.; thickness 0.25 mm.

Specimens were rare in the Timms Point material. d'Orbigny's original description of this species was based on material from the coast of Peru. It was not observed in the Pleistocene of Lomita Quarry.

CASSIDULINA TORTUOSA Cushman and Hughes, n. sp.Plate 2, figs. 4 *a-c*

Test broadly ovate in side view, somewhat irregular, central portion very thick, often equalling half the length, periphery subacute; chambers distinct, six or seven pairs in the last-formed coil, each chamber much curved forming a distinct angle at the central portion; sutures distinct, slightly limbate, with prominent angles; central region with an umbo of clear shell material; aperture elongate, the outer end rounded, tapering to a point at the base, parallel to the axis of coiling.

Length usually not more than 0.50 mm.; thickness 0.10-0.12 mm.

Holotype (Cushman Coll. No. 4338) from the Pliocene of Timms Point, San Pedro, California, where it is abundant. It occurs in fewer numbers in the Pleistocene of Lomita Quarry.

This differs from the other known species of *Cassidulina* in the very much angled chambers, producing a very peculiar arrangement of the sutures, often much more marked than in the figure given. There is also in side view a decidedly spiral twist given to the chambers which is more prominent in this species than any others of the Californian material studied. In the young especially the whole test has an irregular polygonal form.

CASSIDULINA CORBYI Cushman and Hughes, n. sp.Plate 2, figs. 3 *a, b*

Test oval, about one and a half times as long as broad, the periphery strongly serrate, central portion slightly umbilicate, periphery acute, six or seven pairs of chambers in the last-formed coil; chambers angled at the periphery; sutures fairly straight, slightly depressed, not limbate; wall smooth; aperture elongate in the axis of coiling, narrow.

Length 0.50 mm.; thickness 0.20 mm.

Holotype (Cushman Coll. No. 4339) from half a mile north of the Southern Pacific R. R. and a half mile west of Ventura River, Ventura County, California.

This species was collected by Grant W. Corby.

This very distinct species resembles *Cassidulina elegans* Sidebottom, described from the Southwest Pacific, more than any other of the known species of this genus. It may be easily distinguished from other species by the very strongly serrate periphery and the peculiar shape of the chambers. The last-formed chamber has an obliquely truncate border.

CASSIDULINA TRANSLUCENS Cushman and Hughes, n. sp.

Plate 2, figs. 5 a-c

Test nearly circular in side view with a very distinct, broad, thin carina independent of the individual chambers, in apertural view broadly oval, six or seven pairs of chambers making up the last-formed coil, only slightly overlapping, the chambers themselves rhomboid, the long sides nearly parallel, broadest at the outer end, central portion of the test translucent, showing the earlier chambers even to the proloculum; sutures fairly distinct but not marked at the surface; aperture elongate in the axis of coiling, with a very long, narrow, thin tooth on the inner side; wall smooth, polished.

Length 0.60 mm.; thickness 0.30 mm.

Holotype (Cushman Coll. No. 4340) Pleistocene, Lomita Quarry, Palos Verdes Hills, Los Angeles County, California. This species is also found less commonly in the Upper Pliocene of California.

It may be distinguished from the other Californian species by its broad, thin, transparent carina, and by the peculiar translucent appearance of the test, the central portion of which is clear and transparent, through which the earlier chambers may be seen.

CASSIDULINA SUBGLOBOSA H. B. Brady, var. **QUADRATA** Cushman and Hughes, n. var.

Plate 2, figs. 7 a-c

Test in side view nearly circular, the periphery very slightly if at all lobulate, in apertural view roughly quadrangular, length and thickness about equal, the thickness often being slightly greater than the length; chambers fairly distinct but not usually projecting much, if any, above the general outline, five or six pairs in the last-formed coil; sutures distinct, slightly limbate, very little if at all depressed; wall smooth, matte; aperture somewhat rounded, nearly in the axis of coiling, usually with a triangular or flattened tooth projecting into the aperture.

Length up to 1 mm.

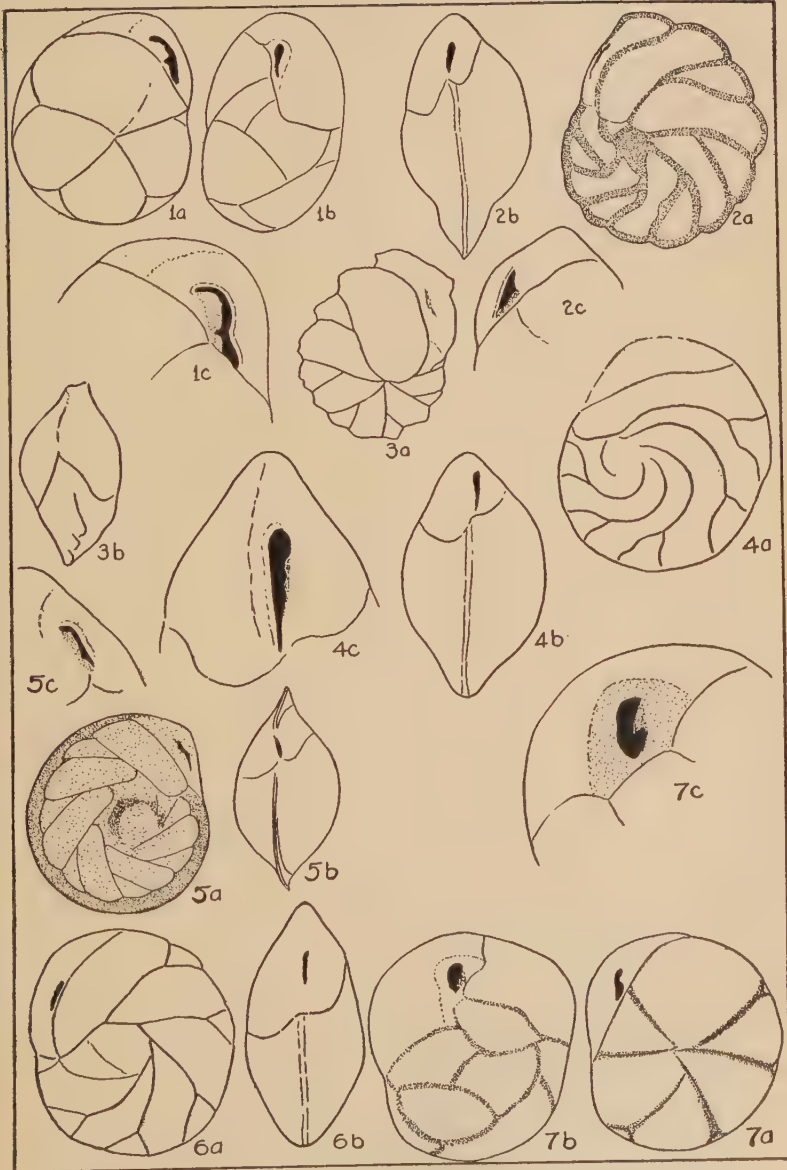
Holotype (Cushman Coll. No. 4341) Pleistocene, Lomita Quarry, Palos Verdes Hills, Los Angeles County, California.

This variety seems to be confined in the California material to the Pleistocene. It differs from typical *Cassidulina subglobosa* H. B. Brady in the less inflated chambers, the quadrangular form, and in the aperture, which in typical *C. subglobosa* is placed in a very distinct angle with the axis of coiling in each

newly added chamber, whereas in the variety it is very close to the axis of coiling. This variety does not show the radiating ridges about the aperture that are a characteristic of typical *C. subglobosa* in recent material.

EXPLANATION OF PLATE 2

- FIGS. 1 *a-c*. *Cassidulina californica* Cushman and Hughes, n. sp.
a, side view; *b*, peripheral view. X 30.
c, details of aperture more enlarged. X 50.
- FIGS. 2 *a-c*. *Cassidulina limbata* Cushman and Hughes, n. sp.
a, side view; *b*, peripheral view. X 40.
c, details of aperture more enlarged. X 75.
- FIGS. 3 *a, b*. *Cassidulina corbyi* Cushman and Hughes, n. sp.
a, side view; *b*, peripheral view. X 50.
- FIGS. 4 *a-c*. *Cassidulina tortuosa* Cushman and Hughes, n. sp.
a, side view; *b*, peripheral view. X 60.
c, details of aperture more enlarged. X 125.
- FIGS. 5 *a-c*. *Cassidulina translucens* Cushman and Hughes, n. sp.
a, side view; *b*, peripheral view. X 50.
c, details of aperture more enlarged. X 100.
- FIGS. 6 *a, b*. *Cassidulina pulchella* d'Orbigny.
a, side view; *b*, peripheral view. X 45.
- FIGS. 7 *a-c*. *Cassidulina subglobosa* H. B. Brady, var. *quadrata* Cushman and Hughes, n. var.
a, side view; *b*, peripheral view. X 40.
c, details of aperture more enlarged. X 100.



6. SOME NEW FORAMINIFERA FROM THE VELASCO
SHALE OF MEXICO

By JOSEPH A. CUSHMAN

Plate 3

In the Velasco shale, which is the uppermost portion of the Upper Cretaceous in the Panuco Section of Mexico, there is a very rich fauna of foraminifera. Many of these species are very close to or identical with species described from the uppermost Cretaceous of Europe. There are, however, a number of species which on close comparison with the European forms appear to be distinct. Some of these more striking ones are described in this paper. They are mostly from the Forns Lease of the Marland Oil Company of Mexico, and to that Company my thanks are due for the privilege of publishing these new forms.

TEXTULARIA VELASCOENSIS Cushman, n. sp.Plate 3, figs. 1 *a-c*

Test in front view oval, the initial end pointed, remainder of the test rather broadly oval, widest near the middle, in end view elliptical with the ends somewhat truncate; chambers comparatively few in number, fairly distinct except in the earlier portion; sutures distinct and limbate, raised; surface ornamented by the limbate sutures between which are raised projections extending back from the sutures themselves onto the lateral surfaces of the chambers with other irregular, raised areas, the sides of the test less ornamented but in some specimens with a continuation of the same irregular, raised surface ornamentation; aperture elongate, low.

Length up to 0.75 mm.; breadth 0.55 mm.; thickness 0.35 mm.

Holotype (Cushman Coll. No. 4343) from the Velasco shale, Tamalte Arroyo, Hacienda El Limon, State of San Luis Potosi, Mexico.

This is a very distinct species, and the type of ornamentation is a very rare one for this genus.

PULVINULINA VELASCOENSIS Cushman, n. sp.

Plate 3, figs. 5 a-c

Test plano-convex, the dorsal side flat or even slightly concave, ventral side very much produced, periphery carinate, subacute, ventral side with the chambers very much prolonged into a distinct projecting mass, the series of which surrounds a depressed umbilical area; about seven chambers in the last-formed coil, distinct; sutures distinct, on the dorsal side curved, marked by a series of small, beadlike processes, the periphery of each with a slightly raised carina which marks also the line of coiling in the central portion, ventral side with the sutures nearly radiate, straight, much depressed, surface roughened with very minute, low spinose processes which rather uniformly cover the entire test; aperture elongate, narrow, on the ventral side of the last-formed chamber extending from near the periphery almost to the umbilical area.

Diameter 0.65 mm.; thickness 0.40 mm.

Holotype (Cushman Coll. No. 4347) from the Velasco shale, Tamalte Arroyo, Hacienda El Limon, State of San Luis Potosi, Mexico.

This is a very abundant species in the Velasco shale of this region, appearing in several forms, some of which may be worthy of distinction. It is distinguished by the very finely spinose surface, especially by the ring of projecting masses surrounding the umbilical area on the ventral side, and the ornamentation a solid, raised carina and beaded sutures.

GLOBIGERINA VELASCOENSIS Cushman, n. sp.

Plate 3, figs. 6 a-c

Test much compressed, the dorsal side with all the chambers visible, ventral side only those of the last-formed coil, sides nearly parallel, periphery broadly rounded; chambers distinct, three or four making up the last-formed coil, early chambers subglobular, later ones becoming more compressed, and the inner margin fairly straight; wall finely and evenly reticulate; aperture on the ventral side, elongate.

Diameter 0.45 mm.; thickness 0.25 mm.

Holotype (Cushman Coll. No. 4348) from the Velasco shale, Tamalte Arroyo, Hacienda El Limon, State of San Luis Potosi, Mexico.

This is a peculiar species in its very much compressed form, the nearly straight inner margin of the chambers, and the much finer reticulate surface than usually occurs in this genus.

GAUDRYINA VELASCOENSIS Cushman, n. sp.Plate 3, figs. 7 *a*, *b*

Test elongate, about twice as long as broad, the early half generally triangular in transverse section, the later half quadrangular, the angles of the early portion very broadly rounded; chambers in the earlier triserial portion indistinct, in the later biserial portion somewhat more distinct; sutures indistinct except between the last three or four chambers, where they are slightly depressed; wall in the early triserial portion with numerous fine, longitudinal striations, the later portion smooth and rather coarsely punctate; aperture very elongate, low.

Length 0.70 mm.; breadth 0.40 mm.

Holotype (Cushman Coll. No. 4349) from the Velasco shale, Tamalte Arroyo, Hacienda El Limon, State of San Luis Potosi, Mexico.

This species is very distinct in the Velasco shale, characterized by its coarsely punctate wall, finely striate early portion with very rounded angles, and the later portion quadrangular.

TRUNCATULINA VELASCOENSIS Cushman, n. sp.Plate 3, figs. 2 *a-c*

Test nearly bilaterally symmetrical with a very thin, broad keel, chambers all visible from the dorsal side, only those in the last-formed coil from the ventral side, about ten chambers in the last-formed coil, fewer in the earlier ones; chambers distinct, especially from the ventral side; sutures on the dorsal side raised and confluent, on the ventral side slightly depressed, curved; wall smooth on the ventral side, the dorsal side with an excavated area over each chamber; aperture elongate, narrow, on the ventral side of the last-formed chamber nearly in the axis of coiling.

Length slightly more than 0.50 mm.; breadth about the same; thickness 0.30 mm.

Holotype (Cushman Coll. No. 4344) from the Velasco shale, 5 km. S. W. of La Bolsa, on W. side of the Moctezuma River, Hacienda Santa Ines, State of San Luis Potosi, Mexico.

This species is very distinctive in the Velasco shale by the thickened limbate sutures, which become confluent on the dorsal side, leaving well-marked, depressed areas over the chambers, and by the very broad, thin keel surrounding the periphery of the test.

ANOMALINA VELASCOENSIS Cushman, n. sp.Plate 3, figs. 3 *a-c*

Test plano-convex, the dorsal side nearly flat, ventral side very broadly rounded, periphery broadly rounded; chambers fairly distinct, eight or nine in the last-formed coil, on the dorsal side there is a depressed area coinciding with the line of coiling, the central portion raised in a spiral, later chambers with a slightly depressed area over each chamber, the sutures being somewhat limbate and raised, on the ventral side sutures limbate but not raised above the general surface, curved, in the edge view the thickenings of the dorsal side often stand up slightly above the general surface; wall generally smooth and finely punctate.

Length about 0.50 mm.; breadth 0.45 mm.; and thickness 0.35 mm.

Holotype (Cushman Coll. No. 4345) from the Velasco shale, Tamalte Arroyo, Hacienda El Limon, State of San Luis Potosi, Mexico.

This is a widely distributed species throughout most of the Velasco formation, and may be distinguished by the very different characters of the dorsal and ventral surfaces, the peculiar spiral thickening of the dorsal side being especially marked.

NODOSARIA LIMONENSIS Cushman, n. sp.Plate 3, figs. 4 *a, b*

Test elongate, subconical, widest near the base, circular in transverse section; chambers indistinct from the surface; sutures indistinct; wall ornamented by a series of eight broad, prominent, longitudinal costae, which toward the base become bifurcate, between these above the early portion, are very thin, delicate, longitudinal costae, alternating with the thick ones; aperture somewhat projecting, radiate.

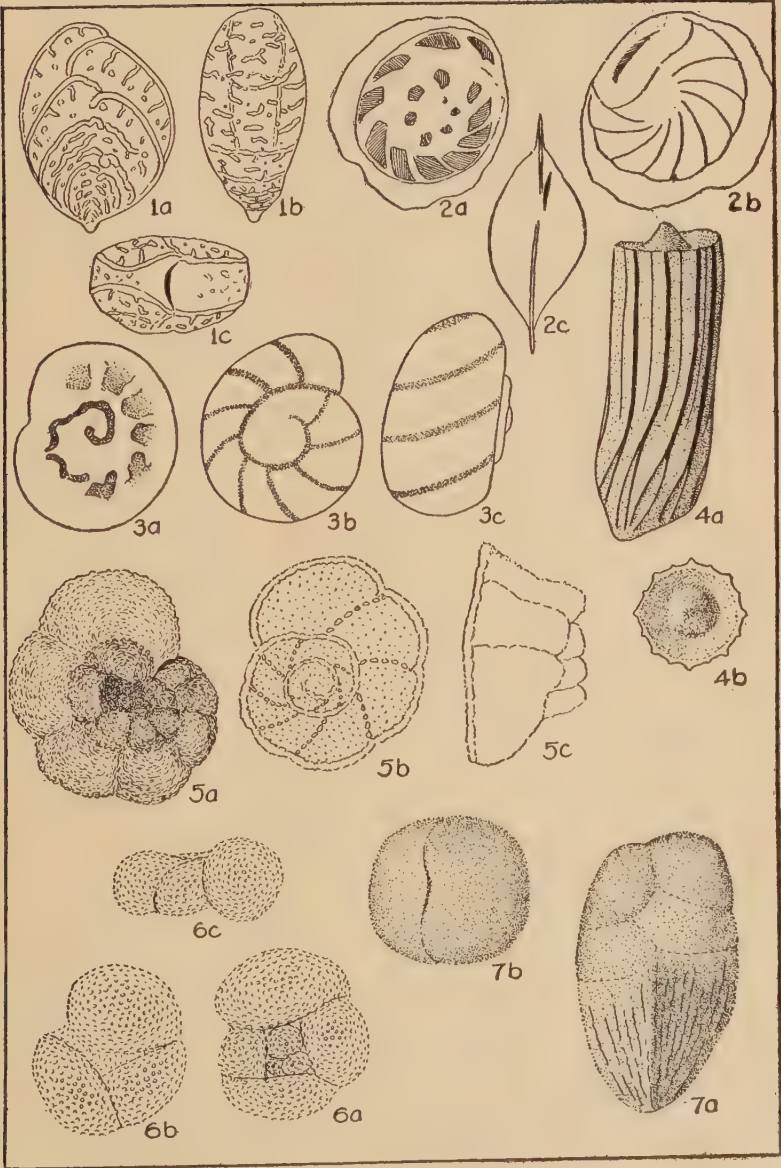
Length of type specimen, which is evidently incomplete, 0.85 mm.; breadth at base 0.25 mm.

Holotype (Cushman Coll. No. 4346) from the Velasco shale, Tamalte Arroyo, Hacienda El Limon, State of San Luis Potosi, Mexico.

This is a very unusual ornamentation and is a very marked character in this species, the early portion with the bifurcate sutures, which coalesce into one stronger, broader costa, and alternating thin, delicate ones will serve to distinguish this from any of the other species of the Mexican Cretaceous.

EXPLANATION OF PLATE 3

- FIGS. 1 *a-c*. *Textularia velascoensis* Cushman, n. sp. X 35.
a, front view; *b*, side view; *c*, apertural view.
- FIGS. 2 *a-c*. *Truncatulina velascoensis* Cushman, n. sp. X 50.
a, dorsal view; *b*, ventral view; *c*, peripheral view.
- FIGS. 3 *a-c*. *Anomalina velascoensis* Cushman, n. sp. X 50.
a, dorsal view; *b*, ventral view; *c*, peripheral view.
- FIGS. 4 *a, b*. *Nodosaria limonensis* Cushman, n. sp. X 50.
a, front view; *b*, apertural view.
- FIGS. 5 *a-c*. *Pulvinulina velascoensis* Cushman, n. sp. X 50.
a, ventral view; *b*, dorsal view; *c*, peripheral view.
- FIGS. 6 *a-c*. *Globigerina velascoensis* Cushman, n. sp. X 50.
a, dorsal view; *b*, ventral view; *c*, peripheral view.
- FIGS. 7 *a, b*. *Gaudryina velascoensis* Cushman, n. sp. X 50.
a, front view; *b*, apertural view.



7. APERTURAL CHARACTERS IN CRISTELLARIA WITH
DESCRIPTION OF A NEW SPECIES

By JOSEPH A. CUSHMAN

In the Miocene Monterey shales of California there is a large, very fine species of *Cristellaria*, the apertural characters of which are particularly interesting, from the bearing they have on other species of the genus. It is a close coiled form in its young, later developing an uncoiled portion, consisting of three or four chambers in the adult. The apertural end projects somewhat above the general outline of the chamber. Viewed from without, this is a radiate aperture, but when the last-formed chamber is broken the interior characters are very interesting. Plate 4, fig. 12 shows the characters of the outer wall of the last-formed chamber viewed from within. Instead of the outer, radiate aperture being seen there is a rounded opening into a secondary chamber, which will here be termed the apertural chamberlet. About this circular aperture is a thin, circular or oval plate, much thinner than the wall of the test itself. Beyond it as shown diagrammatically in figure 13 is a small chamberlet connecting this rounded opening with the outside radiate aperture characteristic of this genus. A number of other specimens showed this same character, so it is not in any way abnormal. Other species of *Cristellaria* were broken in a similar manner, and revealed characters not unlike those figured here.

A further examination of the early chambers of *Cristellaria* has shown that some of them at least do not keep this chamberlet as growth progresses. The use of such a structure as this may become apparent from a study of the life history of the foraminifera. It is known that in the microspheric form the contained protoplasm breaks up into a great many small portions, each with its individual nucleus. These, then, break out from the parent test and form new individuals. In some cases, the early one or two chambers of the new are formed before the young leaves the parent test. In such cases as in *Orbitolites* the outer wall becomes thin and breaks down, allowing the escape of the contained young. Also as an individual foraminifer adds new chambers the single nucleus works its way through to later chambers. This process might be rather difficult where

very small apertures between chambers exist. Apparently in some species at least of *Cristellaria* this outer radiate aperture becomes enlarged by resorption of the wall, and the inner rounded aperture becomes the connection between adjacent chambers. The thin, circular plate about this inner aperture might very easily be a provision for a greater enlargement of the inner aperture by resorption without weakening the general wall of the test. A similar apertural chamberlet should be looked for in other groups of the Lagenidae, where radiate apertures are the rule. The species may be described as follows:

CRISTELLARIA BEALI Cushman, n. sp.

Plate 4, figs. 6-13

Test large, in the early portion close coiled and with a sub-acute periphery in the adult, uncoiled with three or four inflated chambers, the last-formed one broadly triangular in transverse section, with broadly rounded angles; chambers distinct; sutures distinct, with a very decided angle toward the periphery, more marked in the adult portion where they are somewhat depressed, those of the early coiled portion distinct but not depressed; wall smooth and shining; aperture radiate with an internal apertural chamberlet, the inner wall of which has a circular opening about which is a thin plate.

Length 1.05 mm. or slightly more; thickness 0.30 mm.

Holotype (Cushman Coll. No. 4342) from Monterey shale, Sect. 24, T.28S., R.14E., San Luis Obispo County, California, collected by W. D. Kleinpell.

The species is named for Carl Beal, geologist of California.

In some respects *Cristellaria beali* resembles *C. arcuata* d'Orbigny but is a larger, stouter species, and the peculiarly angled character of the sutures of the California species will easily distinguish it.

EXPLANATION OF PLATE 4

- FIGS. 1 *a-c.* *Uvigerina seligi* Cushman, n. sp.
a, b, side views; *c*, apertural view. X 150.
- FIGS. 2 *a-c.* *Uvigerina compressa* Cushman, n. sp.
a, front view; *b*, side view; *c*, apertural view. X 65.
- FIG. 3. *Siphogenerina collomi* Cushman, n. sp. X 35.
- FIG. 4. *Siphogenerina reedi* Cushman, n. sp. X 35.
- FIG. 5. *Siphogenerina kleinpelli* Cushman, n. sp. X 35.
- FIGS. 6-13. *Cristellaria beali* Cushman, n. sp. X 35.
6, 8, 9, 10, side views; 7, front view; 11, apertural view; 12, interior of the last-formed chamber; 13, ideal section of the last-formed chamber showing the thin plate about the inner aperture, the apertural chamberlet outside with the radiate aperture.





RECENT LITERATURE ON THE FORAMINIFERA

Below are given some of the more recent works on the foraminifera that have come to hand.

Silvestri, A.

Fauna paleogenica di Vasciano presso Todì.

(Boll. Soc. Geol. Ital., vol. 42, 1923 (1924), pp. 7-29, pl. 1, text figs. A, B.)

Fifteen species and varieties are recorded with notes, with a double plate from micro-photographs, from the lower Tertiary of Central Italy.

Dollfus, R. P.

Contribution à la faune des Invertébrés du banc de Rockall.

(Bull. Instit. Oceanographique, No. 438, January 1924, pp. 1-28.)

A list of species, identified by Heron-Allen and Earland from the Rockall Bank, is given on pp. 5-9 with a few notes.

Heron-Allen, E. and Earland, A.

The Foraminifera of Lord Howe Island, South Pacific.

(Journ. Linn. Soc., Zoology, vol. 35, April 1924, pp. 599-647, pls. 35-37.)

One hundred ninety-nine species are noted from shallow-water material of this South Pacific island. Two new genera are described, *Diffusilina* and *Craterites*. Seven new species and varieties are described.

Paalzow, R.

Foraminiferen aus den Cerithiensanden von Offenbach a. M.

(Bericht Offenbacher Vereins für Naturkunde, 1924, pp. 7-28, pls. 1, 2.)

Twenty-three species are noted from this Oligocene material from Germany. Two new species are described.

Van der Vlerk, I. M.

Foraminiferen uit het Tertiair van Java.

(Wetenschappelijke Mededeelingen, No. 1, 1924, 19 pages, pls. 3-5.)

Fifteen species and varieties are noted and most of them figured from photomicrographs. Seven new species and varieties are described from this later Tertiary of Java.

Van der Vlerk, I. M.

Miogypsina Dehaartii, nov. spec., de Larat (Moluques).

(*Eclogae geologicae Helvetiae*, vol. 18, No. 3, 1924, pp. 429-432, 3 text figs.)

This short paper describes and figures a new species of *Miogypsina* found in the late Tertiary at Larat, an island off the southeast coast of Dutch New Guinea.

Cushman, J. A.

The Foraminifera of the Atlantic Ocean, Pt. V, Chilostomellidae and Globigerinidae.

(Bull. 104, U. S. Nat. Mus., pt. 5, 1924, pp. 1-55, pls. 1-8.)

Heron-Allen, E. and Earland, A.

The Miocene Foraminifera of the "Filter Quarry," Moorabool River, Victoria, Australia.

(Journ. Roy. Micr. Soc., June 1924, pp. 121-186, pls. 7-14.)

Two hundred and seventy species and varieties are noted from this Australian lower Tertiary. There are twenty new species and varieties described.

Hanna, G. D. and Hanna, M. A.

Foraminifera from the Eocene of Cowlitz River, Lewis County, Washington.

(Univ. Washington Publ. in Geol., vol. 1, No. 4, Oct. 1924, pp. 57-62, pl. 13.)

Ten species are described and figured of which five are described as new.

Cushman, J. A.

Samoan Foraminifera.

(Carnegie Institution of Washington, Publ. 342, Oct. (Nov.) 1924, pp. 1-75, pls. 1-25.)

This paper records one hundred fifty-five species and varieties of recent foraminifera from Pago Pago Harbor, Samoa. A table of distribution is given showing some of the Indo-Pacific distribution of the species. One new genus, *Rotaliammina*, is described and twenty-four new species and varieties.

Cushman, J. A.

A New Genus of Eocene Foraminifera.

(Proc. U. S. Nat. Mus., vol. 66, 1924, pp. 1-4, pls. 1, 2; 1 text fig.)

A new genus, *Hantkenina*, is described with several new species from the Upper Eocene of Mexico and the United States.

CONTRIBUTIONS FROM THE CUSHMAN LABORATORY FOR FORAMINIFERAL RESEARCH

VOLUME 1, PART 2, JULY 1925

8. SOME TEXTULARIIDAE FROM THE MIOCENE OF CALIFORNIA

By JOSEPH A. CUSHMAN

Plate 5

A close study of some of the Textulariidae from the Monterey shale of the Miocene of California has shown that the stratigraphic data makes distinct many closely allied species. The differences when individual specimens, such as those figured on Plate 5, are shown together are not so striking as when groups of individuals from the same stratigraphic levels are compared with one another.

All the specimens recorded in this paper are from Miocene Monterey shales, Sect. 24, T.28S., R.14E., San Luis Obispo County, California, collected by W. D. Kleinpell.

BOLIVINA ADVENA Cushman, n. sp.

Plate 5, figs. 1 *a*, *b*

Test of early portion compressed, later portion thickened; early chambers low, close-set, later ones higher; sutures of early portion slightly limbate, later portion very narrow, somewhat depressed, periphery of early portion acute, later rounded; wall smooth but distinctly punctate.

Length up to 0.60 mm.; breadth 0.22 mm.

Holotype (Cushman Coll. No. 4350).

BOLIVINA ADVENA Cushman, n. sp., var. **ORNATA** Cushman, n. var.

Plate 5, figs. 2 *a*, *b*

Variety differing from the typical in the larger size, greater roundness of the later portion, and the addition of numerous longitudinal costae, 10 to 12 on each side of the test.

Length up to 0.75 mm.; breadth 0.30 mm.

Holotype (Cushman Coll. No. 4351).

BOLIVINA ADVENA Cushman, n. sp., var. **STRIATELLA** Cushman, n. var.Plate 5, figs. 3 *a, b*

Variety differing from the typical in the longer, more tapering form, initial end subacute, about 9 chambers making up the last half of the test; sutures somewhat distinct, very slightly depressed; wall finely punctate, surface of the early portion ornamented with very fine, numerous, longitudinal costae, the later portion smooth.

Length up to 0.85 mm.; breadth 0.22 mm.

Holotype (Cushman Coll. No. 4352).

BOLIVINA CONICA Cushman, n. sp.Plate 5, figs. 4 *a, b*

Test rapidly tapering from the subacute initial end, very slightly compressed, periphery rounded, whole test in section circular; sutures and chambers indistinct; wall punctate, the early portion ornamented with very fine longitudinal costae, 15 to 20 in each side, all of about equal strength; later part of the test coarsely punctate.

Length 0.50 mm.; breadth 0.20 mm.

Holotype (Cushman Coll. No. 4352).

This somewhat resembles a species I have figured (Bull. 103, U. S. Nat. Mus., 1918, p. 54, pl. 21, fig. 3) from the Gatun Miocene of the Panama Canal Zone.

BOLIVINA MARGINATA CushmanPlate 5, figs. 5 *a, b*

Bolivina marginata CUSHMAN, Bull. 676, U. S. Geol. Surv., 1918, p. 48, pl. 10, fig. 1.

Test much compressed, of medium size for the genus, periphery acute, keeled throughout; sutures usually distinctly limbate, oblique; chambers numerous, distinct, 7 or 8 chambers making up the last half of the test; wall thin, rather coarsely punctate, surface without ornamentation; aperture elongate, narrow.

Length 0.65 mm.; breadth 0.25 mm.

This species was originally described from the Choctawhatchee Marl, one mile south of Red Bay, Florida. The specimens from the California Miocene are very close to the Florida ones, but are somewhat smaller.

BOLIVINA DECUSSATA H. B. BradyPlate 5, figs. 6 *a*, *b*

Bolivina decussata H. B. BRADY, Quart. Journ. Micr. Sci., vol. 21, 1881, p. 58; Rep. Voy. *Challenger*, Zoology, vol. 9, 1884, p. 423, pl. 53, figs. 12, 13.—Cushman, Bull. 71, U. S. Nat. Mus., pt. 2, 1911, p. 47, fig. 77 (in text).—Sidebottom, Journ. Roy. Micr. Soc., 1918, p. 128.—Cushman, Bull. 104, U. S. Nat. Mus., pt. 3, 1922, p. 32.—Heron-Allen and Earland, British Antarctic Exped., Zoology, vol. 6, 1922, p. 134.

Test stout, tapering, rapidly increasing in size from the narrowly rounded initial end, periphery squarely truncate or even slightly concave; chambers numerous, the last 6 making up more than half the test; sutures usually indistinct, sinuous, following the lobes and reëntnants of the basal part of the chamber; wall thick, punctate, surface with knoblike thickenings alternating with rounded depressions; aperture semicircular or somewhat rectangular, without a definite lip.

Length 0.65 mm.; breadth 0.30 mm.

All records which are unquestionably of this species are from the Pacific.

BOLIVINA IMBRICATA Cushman, n. sp.Plate 5, figs. 7 *a*, *b*

Test much compressed, of medium size for the genus, periphery acute, keeled throughout; sutures distinctly limbate, much curved; chambers numerous, distinct, 8 chambers making up the last half of the test; wall thin, very finely punctate, surface with longitudinal costae, 8 to 10 on each side, the costae for the most part limited to the first third of the test except the central costa which is the most prominent and often continues nearly to the apertural end of the test.

Length up to 0.75 mm.; breadth 0.30 mm.

Holotype (Cushman Coll. No. 4355).

In its fully developed characters the chambers are decidedly imbricate, the basal half of each overlapping the anterior half of the preceding chamber. The test often becomes thick and the wall coarsely perforate.

BOLIVINA BREVIOR Cushman, n. sp.Plate 5, figs. 8 *a*, *b*

Test minute, compressed, tapering from a subacute initial end, periphery broadly rounded throughout; chambers comparatively few, the last 6 making up more than half the test; sutures distinct, very slightly depressed; wall distinctly punctate.

Length up to 0.40 mm.; breadth 0.13-0.16 mm.

Holotype (Cushman Coll. No. 4356).

This species is smaller and much more compressed than *Bolivina tumida* Cushman, n. sp., which it resembles in some respects. The two are not found together, however.

BOLIVINA TUMIDA Cushman, n. sp.

Plate 5, figs. 9 *a*, *b*

Test comparatively small, only slightly compressed, tapering from a subacute initial end, periphery broadly rounded throughout; chambers numerous, high, the last 5 making up more than half the test; sutures distinct, very slightly depressed, nearly at right angles to the periphery, the later ones slightly oblique; wall distinctly punctate.

Length up to 0.50 mm.; breadth 0.20 mm.

Holotype (Cushman Coll. No. 4357).

BOLIVINA CALIFORNICA Cushman, n. sp.

Plate 5, figs. 10 *a*, *b*

Test fusiform, twisted, rapidly increasing in size from the subacute initial end, greatest width near the middle, thence slightly decreasing in width toward the apertural end, periphery broadly rounded; chambers numerous, distinct, somewhat inflated, the last 5 or 6 making up half the test; sutures distinct, slightly depressed; surface ornamented with longitudinal costae especially developed over the sutures, usually absent in the middle portion of the chambers; aperture elongate with a slight lip.

Length 0.60 mm.; breadth 0.22 mm.

Holotype (Cushman Coll. No. 4358).

VIRGULINA CALIFORNIENSIS Cushman, n. sp.

Plate 5, figs. 11 *a-c*

Test slightly more than twice as long as broad; early chambers spiral, later ones biserial, not twisted, periphery broadly rounded, the last 3 chambers making up nearly half the test, initial end subacute, apertural end broadly rounded, early chambers small, indistinct, later ones inflated, very distinct, biserial; sutures of the early portion indistinct, later ones very distinct, depressed; wall smooth but distinctly punctate; aperture comma-shaped.

Length 0.50 mm.; breadth 0.22 mm.

Holotype (Cushman Coll. No. 4359).

BULIMINELLA SUBFUSIFORMIS Cushman, n. sp.

Plate 5, fig. 12

Test spiral, much elongate, subcylindrical, early portion tapering, sides for most of the test nearly parallel, periphery lobulate; chambers numerous, inflated, distinct, 3 or 4 making up a coil; sutures distinct, depressed; wall smooth, very finely punctate; aperture narrow, elongate.

Length 0.60 mm.; breadth 0.20 mm.

Holotype (Cushman Coll. No. 4360).

This may be distinguished from *Buliminella curta* Cushman, n. sp., by the nearly parallel sides, and from *Buliminella brevior* Cushman, n. sp., by the distinct lobing of the periphery and the much more inflated chambers, as well as the much more elongate form with fewer chambers in each coil.

BULIMINELLA CURTA Cushman, n. sp.

Plate 5, fig. 13

Test spiral, tapering or fusiform, initial end rounded thence rapidly increasing in diameter nearly to the apertural end, periphery slightly lobulate; chambers numerous, 5 or 6 making up a coil in the adult, distinct, inflated; sutures distinct, slightly depressed; wall smooth, very finely punctate; aperture comma-shaped in a slightly concaved depression of the last-formed chamber.

Length 0.45-0.50 mm.; breadth 0.25 mm.

Holotype (Cushman Coll. No. 4361).

BULIMINELLA BREVIOR Cushman, n. sp.

Plate 5, fig. 14

Test short, broad, the initial end somewhat pointed, composed of about two whorls, the last-formed one of numerous chambers; sutures slightly depressed, the aperture at face involving the sides of several chambers.

Length 0.50 mm.; breadth 0.30 mm.

Holotype (Cushman Coll. No. 4362).

This resembles some of the forms from the Mediterranean and late Tertiary of this region.

BULIMINELLA CALIFORNICA Cushman, n. sp.

Plate 5, fig. 15

Test spiral, subcylindrical, much elongate, sides nearly parallel, early portion gently tapering from a subacute initial end, periphery very slightly or not at all lobulate; chambers numerous, 4 or 5 making up a coil in the adult, not inflated; sutures

very slightly if at all depressed, often indistinct, sometimes strongly limbate; wall fairly thick, very finely punctate, smooth; aperture either comma-shaped at the base of the last-formed chamber or rounded and terminal.

Length 0.50-0.55 mm.; breadth 0.15 mm.

Holotype (Cushman Coll. No. 4363).

This may be distinguished from all the other *Buliminellas* of this section by the limbate sutures, and the sides which are not lobulate.

CASSIDULINA PULCHELLA d'Orbigny

Plate 5, fig. 16

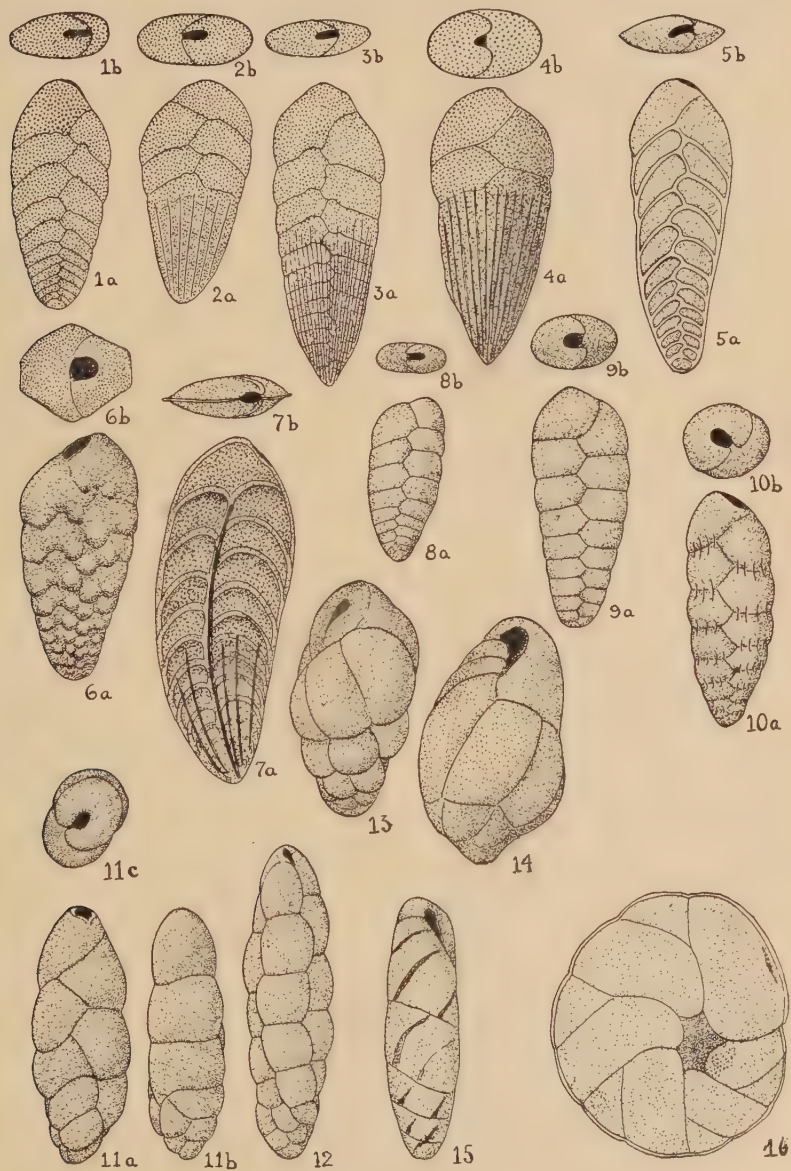
Cassidulina pulchella D'ORBIGNY. Voy. Amér. Mér., 1839, "Foraminifères", p. 57, pl. 8, figs. 1-3.—Cushman and Hughes, Contrib. Cushman Lab. Foram. Research, vol. 1, pt. 1, 1925, p. 13, pl. 2, figs. 6 *a*, *b*.

This species known previously from the coast of Peru, and from the Pliocene of California, at Timms Point, seems also to be present in this Miocene California material.

EXPLANATION OF PLATE 5

All figures X 65

- FIG. 1. *Bolivina advena* Cushman, n. sp.
a, front view; *b*, apertural view.
- FIG. 2. *Bolivina advena* Cushman, n. sp., var. *ornata* Cushman, n. var.
a, front view; *b*, apertural view.
- FIG. 3. *Bolivina advena* Cushman, n. sp., var. *striatella* Cushman, n. var.
a, front view; *b*, apertural view.
- FIG. 4. *Bolivina conica* Cushman, n. sp.
a, front view; *b*, apertural view.
- FIG. 5. *Bolivina marginata* Cushman.
a, front view; *b*, apertural view.
- FIG. 6. *Bolivina decussata* H. B. Brady.
a, front view; *b*, apertural view.
- FIG. 7. *Bolivina imbricata* Cushman, n. sp.
a, front view; *b*, apertural view.
- FIG. 8. *Bolivina brevior* Cushman, n. sp.
a, front view; *b*, apertural view.
- FIG. 9. *Bolivina tumida* Cushman, n. sp.
a, front view; *b*, apertural view.
- FIG. 10. *Bolivina californica* Cushman, n. sp.
a, front view; *b*, apertural view.
- FIG. 11. *Virgulina californiensis* Cushman, n. sp.
a, front view; *b*, side view; *c*, apertural view.
- FIG. 12. *Buliminella subfusiformis* Cushman, n. sp.
- FIG. 13. *Buliminella curta* Cushman, n. sp.
- FIG. 14. *Buliminella brevior* Cushman, n. sp.
- FIG. 15. *Buliminella californica* Cushman, n. sp.
- FIG. 16. *Cassidulina pulchella* d'Orbigny.



9. SIPHOGENERINA HUGHESI, A NEW SPECIES FROM CALIFORNIA

By JOSEPH A. CUSHMAN

Smooth species in the genus *Siphogenerina* are very rare. *S. columellaris* H. B. Brady and *S. bifrons* H. B. Brady, both recent species, are the only ones. *S. glabra* Schlumberger is a synonym of the first. *S. bifrons* is a peculiarly compressed and excavated species, leaving *S. columellaris* as the only one at all like this new one.

SIPHOGENERINA HUGHESI Cushman, n. sp.

Plate 7, figs. 4 *a*, *b*

Test elongate, fairly thick, two or three times as long as broad, circular in transverse section; chambers short and broad, the early chambers irregularly spiral, later ones uniserial; sutures distinct and depressed; wall thick, the exterior smooth throughout; aperture terminal, rounded, with a short neck and slight lip.

Length 1 mm. or slightly more; breadth 0.50 mm.

Holotype (Cushman Coll. No. 4364) from the Miocene Monterey shales near Chimney Rock, San Luis Obispo County, California.

The species is named for Donald D. Hughes, palaeontologist of California.

10. NEW SPECIES OF CASSIDULINA FROM THE PACIFIC

By JOSEPH A. CUSHMAN

A study of recent Pacific material has shown one very striking species of *Cassidulina*, and a comparison with other areas has shown that a second of these should be distinguished as new. As a rule the Pacific shows much more ornate and bizarre forms than those of any other region. Notes on these species follow:

CASSIDULINA ELEGANTISSIMA Cushman, n. sp.Plate 7, figs. 5 *a*, *b*

Test somewhat compressed, nearly circular in outline, the periphery subacute, with a projecting spine on each of the newly added chambers, often wanting in the older part of the last-formed coil; chambers numerous, 5 or 6 pairs making up the last-formed coil, chambers elongate, curved; the sutures, except in the last-formed chamber, almost completely obscured by the surface ornamentation which consists of irregular, polygonal reticulations formed by rather distinct, sharp, raised regions of the surface; the aperture elongate, narrow, slightly below the periphery, but parallel to it.

Diameter up to 1 mm., including spines; breadth 0.40 mm.

Holotype (U. S. N. M. Coll. No. 20,278), from *Nero* station 427, in the North Pacific, between Midway Island and Guam, 1,997 fathoms.

This species is distinct from any of the known *Cassidulinas* in its surface ornamentation. It remotely resembles *Cassidulina decorata* Sidebottom, described from the Southwest Pacific. In the apertural view the spines alternate from side to side, as shown in Plate 7, figure 5 *b*.

CASSIDULINA ORIENTALE Cushman, n. sp.Plate 7, figs. 6 *a-c*

Cassidulina bradyi H. B. BRADY (in part) (not Norman), Rep. Voy. *Challenger*, Zoology, vol. 9, 1884, p. 431, pl. 54, fig. 10 (not figs. 6-9).

Test much compressed, the periphery rounded; usually 5 or 6 pairs of chambers in the last-formed coil, tending in adult specimens to show a slight uncoiling in latest growth; sutures distinct but very slightly depressed, nearly straight; wall smooth, finely punctate, the periphery near the aperture with a clear space without punctae; aperture an elongate, narrow slit, parallel to the periphery.

Length 0.40 mm.; breadth 0.32 mm.

Holotype (U. S. N. M. Coll. No. 20,279), from *Nero* station 1264, south of Japan, in 2,080 fathoms.

This species, which is apparently widely spread in the Pacific, was combined by Brady with *Cassidulina bradyi* Norman, which in its typical form seems to be a species of the northeastern Atlantic. Plate 54, figs. 6-9 of the *Challenger* report are from a *Porcupine* station off the British Isles; fig. 10 is probably the form recorded by numerous authors from the Pacific under the name of *C. bradyi*.

CASSIDULINA PARKERIANA H. B. BradyPlate 7, figs. 7 *a-c*

Cassidulina parkeriana H. B. BRADY, Quart. Journ. Micr. Sci., vol. 21, 1881, p. 59; Rep. Voy. *Challenger*, Zoology, vol. 9, 1884, p. 432, pl. 54, figs. 11-16.

There is a very finely developed specimen of this species from *Nero* station 1702, in the North Pacific, between Guam and Midway Island, 1,854 fathoms. The distribution of this species seems to be Indo-Pacific in comparatively deep water except in the Antarctic.

11. RECENT FORAMINIFERA FROM BRITISH COLUMBIA

By JOSEPH A. CUSHMAN

Very little is known of the recent foraminifera of the eastern part of the Pacific, in fact, it is one of the least known regions of the world, as far as the foraminifera are concerned. A small collection from this region, therefore, has been of more than usual interest, and fills in records for this almost unknown area. The species have a very definite relationship with the late Tertiary of California, and probably adjacent regions, as well as with the western coast of South America. At least three of the species described by d'Orbigny from the west coast of South America in 1839 have appeared in typical form in the British Columbian material. Only those species of greatest interest, or undescribed, are referred to in this short paper.

HAPLOPHRAGMOIDES ADVENA Cushman, n. sp.Plate 6, figs. 1 *a, b*

Test compressed, involute, close coiled, umbilicate, periphery broadly rounded; last-formed coil consisting of about 10 chambers, only slightly inflated; sutures distinct, slightly depressed, very slightly curved; wall arenaceous, mostly of fine material but with numerous angular fragments; aperture a low, curved slit at the base of the apertural face.

Length up to 1.25 mm.; breadth 1 mm.

Type specimens from Virago Sound off British Columbia, 8-15 fathoms. It also occurred off Queen Charlotte Island, 20-25 fathoms.

This belongs to the general group of *Haplophragmoides canariensis* (d'Orbigny), but is larger and has more chambers than the typical Atlantic form of that species.

HAPLOPHRAGMOIDES COLUMBIENSIS Cushman, n. sp.

Plate 6, figs. 2 a, b

Test small, compressed, very slightly umbilicate, periphery broadly rounded; chambers few, 6 making up the last-formed coil, broad and slightly covering the umbilicus; sutures distinct, only slightly depressed, radial; wall smoothly finished of fine arenaceous material, with a very few larger angular grains; aperture very narrow at the base, and slightly to one side of the last-formed chamber.

Length 0.80 mm.; breadth 0.60 mm.

Type specimen from Queen Charlotte Sound, 25 fathoms.

This is a rather unusual form with a completely covered umbilicus, and a few chambers very smoothly finished.

TROCHAMMINA PACIFICA Cushman, n. sp.

Plate 6, figs. 3 a-c

Test small, composed of several coils, 4 to 5 chambers in the last-formed one, all the chambers visible from the dorsal side, only those of the last-formed coil from the ventral side, which is umbilicate, periphery rounded; sutures distinct but only slightly depressed, nearly radial; wall finely arenaceous, smoothly finished, of a yellowish brown color, with a few larger fragments; aperture a narrow slit on the ventral side, at the base of the last-formed chamber.

Diameter 0.40 mm.

Type specimen from off Virago Sound, off British Columbia, 8-15 fathoms. It also occurred in Queen Charlotte Sound, 20-25 fathoms.

TROCHAMMINA CHARLOTTENSIS Cushman, n. sp.

Plate 6, figs. 4 a, b

Test somewhat compressed, the periphery rounded, all the chambers visible from the dorsal side, those of the ventral side of the last-formed coil visible, very slightly umbilicate, 4 or 5 chambers in the last-formed coil; sutures very distinct, much curved on the dorsal side, slightly so on the ventral, the suture representing the line of growth of the coils also sharply distinct but not depressed; wall smoothly finished, dark reddish brown; aperture narrow, ventral, near the umbilicus.

Diameter 0.30 mm.

Type specimen from Queen Charlotte Sound, 25 fathoms.

This is very distinct from *Trochammina pacifica* especially in the dorsal surface, which has very distinct, curved sutures, and the ventral side which is much less umbilicate.

BULIMINELLA ELEGANTISSIMA (d'Orbigny)

Plate 6, figs. 5 *a*, *b*

Bulimina elegantissima D'ORBIGNY, Voy. Amér. Mérid., 1839, "Foraminifères," p. 51, pl. 7, figs. 13, 14.

In Virago Sound, 8-15 fathoms, occurred specimens of this species, which are identical with the figured specimens from the west coast of South America given by d'Orbigny. From other parts of the world specimens have been referred to this species, but as a rule they are not so closely identical as are our British Columbian specimens.

CASSIDULINA PULCHELLA d'Orbigny

Cassidulina pulchella D'ORBIGNY, Voy. Amér. Mérid., 1839, "Foraminifères", p. 57, pl. 8, figs. 1-3.—Cushman and Hughes, Contrib. Cushman Lab. Foram. Research, vol. 1, pt. 1, 1925, p. 13, pl. 2, figs. 6 *a*, *b*.

From 25 fathoms, Queen Charlotte Sound, and 8-15 fathoms, Virago Sound, there are specimens which are identical with this species as described and figured by d'Orbigny from the coast of Peru. It has also occurred in the Pliocene of California.

CASSIDULINA TORTUOSA Cushman and Hughes

Cassidulina tortuosa CUSHMAN and HUGHES, Contrib. Cushman Lab. Foram. Research, vol. 1, pt. 1, 1925, p. 14, pl. 2, figs. 4 *a-c*.

This species, already known from the Pliocene and Pleistocene of California, has occurred in typical form in 25 fathoms, Queen Charlotte Sound.

CASSIDULINA CALIFORNICA Cushman and Hughes

Cassidulina californica CUSHMAN and HUGHES, Contrib. Cushman Lab. Foram. Research, vol. 1, pt. 1, 1925, p. 12, pl. 2, figs. 1 *a-c*.

There is a single specimen from Queen Charlotte Sound in 25 fathoms, which is identical with this species recently described from the Pliocene and Pleistocene of California.

CASSIDULINA CHARLOTTENSIS Cushman, n. sp.

Plate 6, figs. 6, 7

Test loosely spiral, somewhat conical or cornucopia shaped, consisting of numerous chambers in an alternating biserial arrangement, initial end pointed, apertural end broadly rounded, in front view one side broadly convex, the other with a reëntrant angle; chambers distinct; sutures distinct, curved, but not depressed; wall smooth, punctate, of a yellowish brown color; aperture elongate at the base of the last-formed chamber.

Length up to almost 1 mm.; breadth of largest specimen 0.55 mm.

Type specimens from Queen Charlotte Sound, 20-25 fathoms.

This species is a peculiar one, in many respects resembling *Buliminella convoluta* (Williamson). A careful study of the specimens, however, seems to show a definite alternating series throughout, and it seems to be a *Cassidulina* of a very unusual type of coiling, not greatly unlike *C. bradyi* Norman in some respects. It also reminds one somewhat of a form recently described by Heron-Allen and Earland as *C. laevigata* d'Orbigny, var. *tumida*, from the Antarctic, in the peculiar alternating and coiled structure. This last resemblance, however, is only very remote.

LAGENA ORBIGNYANA (Seguenza)

Plate 6, fig. 8

A specimen which may be referred to this species occurred in 25 fathoms, Queen Charlotte Sound.

POLYMORPHINA CHARLOTTENSIS Cushman, n. sp.

Plate 6, fig. 9

Test large, tapering slightly from the broadly rounded initial end, compressed, with the periphery rounded; chambers comparatively few, irregularly biserial, peculiarly overlapping at one side; sutures fairly distinct but not depressed; wall smooth; aperture radiate.

Length up to 2 mm. or more; breadth 0.65 mm.

Type specimen from Queen Charlotte Sound, 25 fathoms.

This is probably identical with a large species of *Polymorphina*, which is found in the late Tertiary of California.

SPIRILLINA SPINIGERA Chapman, var. **REDUCTA** Cushman, n. var.

Plate 6, fig. 10

This form resembles Chapman's species, but the border is much less spinose, the channel between the coils is very distinctly depressed, and the general surface somewhat roughened.

Diameter 0.55 mm.

Type specimen from Queen Charlotte Sound, 25 fathoms.

DISCORBIS ORNATISSIMA Cushman, n. sp.

Plate 6, figs. 11, 12

Test of medium size, thick, nearly circular in outline, the dorsal side broadly rounded, ventral side flattened, very slightly umbilicate in the center, the periphery broadly rounded; chambers few, four in the last-formed coil, distinct but not inflated; sutures distinct but not depressed, on the dorsal side gently curved, on the ventral nearly radiate; wall very coarsely punctate on the dorsal side except the broad band over the sutures and about the periphery, ventral side coarsely papillate with numerous inwardly pointing projections about the umbilicus; aperture ventral, narrow.

Diameter up to 0.80 mm.; thickness 0.30 mm.

Type specimens from Virago Sound, 8-15 fathoms. It also occurred in 20-25 fathoms, Queen Charlotte Sound.

This is one of the most common species in this material, a great many of the specimens showing plastogamy, the 2 chambers being attached by the ventral side, as in plate 6, fig. 12. As is usual in such forms as *Discorbis*, one specimen is very much smaller than the other. The two shown in the figures are nearly equal.

DISCORBIS CHARLOTTENSIS Cushman, n. sp.

Plate 7, figs. 2 a, b

Test minute, pyramidal, in a tapering cone with 5 distinct sides, the angles of the sides being the middle of the chamber; chambers few, 5 in each coil, rather indistinct; sutures not depressed except slightly on the ventral side, radiate; wall rather coarsely perforate; aperture ventral, elongate.

Length 0.20 mm.; diameter 0.15 mm.

Type specimens from Queen Charlotte Sound, 25 fathoms.

This is a very small species allied to some of the other pyramidal forms, which seem to be characteristic of the general Pacific region.

DISCORBIS COLUMBIENSIS Cushman, n. sp.Plate 6, figs. 13 *a-c*

Test planoconvex, the dorsal side broadly rounded, ventral side flattened or even concave, the umbilical region much more deeply so, periphery broadly rounded; chambers few, 5 in the last-formed coil, distinct, slightly inflated on the ventral side; sutures distinct, those of the dorsal side gently curved, on the ventral side nearly radiate, that of the last-formed chamber on the ventral side with a distinct angle; wall on the dorsal side becoming more and more coarsely punctate with newly added chambers; aperture umbilicate, elongate.

Diameter 0.33 mm.; thickness 0.15 mm.

Type specimen from Queen Charlotte Sound, 20 fathoms.

This differs from other known species in several characters: the broadly depressed umbilicate region with its peculiarly angled form of the last chamber, the broadening of the chambers in the last-formed coil, and the progressively greater size of the punctae.

PULVINULINA REPANDA Fichtel and Moll

This species, which is typical of tropical and subtropical waters, usually in the vicinity of coral reefs, occurs in this British Columbian material. It is not entirely identical with that from tropical regions, but is very close to material which I have had from Samoa. It is less like the material from coral-reef regions of the West Indies.

PULVINULINA COLUMBIENSIS Cushman, n. sp.Plate 7, figs. 1 *a-c*

Test large, compressed, nearly circular from above, the periphery subacute or rounded, composed in the megalospheric form, which is figured, of but about 2 coils of chambers, the last-formed one with 8 chambers, which is a fairly constant number in the adult, the chambers on the dorsal side very distinct; the sutures clear and limbate, the ventral side very strongly ornamented by a secondary growth of shell material forming an irregular pattern of papillae and bosses, in the last-formed chambers, as in figure 1 *b*, some of the original thin wall of the chambers may be seen; aperture ventral, elongate, between the margin and the umbilical region.

Diameter up to 1.50 mm.; breadth 0.65 mm.

Type specimens from 20 fathoms, Queen Charlotte Sound. It also occurs in Virago Sound, 8-15 fathoms.

This is the largest and most striking species of the collection, and is a very distinctive one; on the dorsal side it resembles some of the other Pacific forms, but the ventral side is distinctive.

NONIONINA AURIS (d'Orbigny)

Plate 7, figs. 3 *a-c*

Valvulina auris D'ORBIGNY, Voy. Amér. Mérid., 1839, "Foraminifères", p. 47, pl. 2, figs. 15-17.

There is a species in this material which very much resembles the above species of d'Orbigny, described from the west coast of South America. It has, however, fewer chambers, and is a somewhat stouter form. It is very similar to a form which occurs in the late Tertiary of California.

CORNUSPIRA INVOLVENS Reuss

There are a few small specimens which may be referred to this species. Miliolidae are scarce in this British Columbian material.

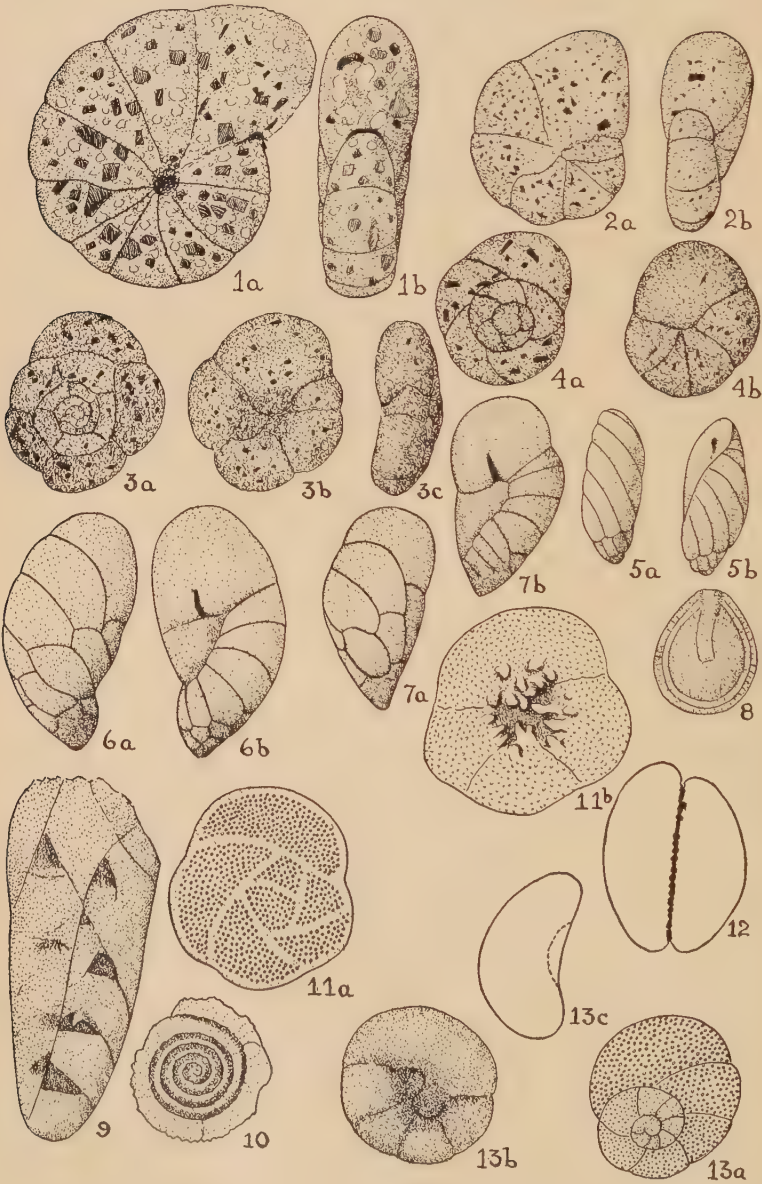
EXPLANATION OF PLATES

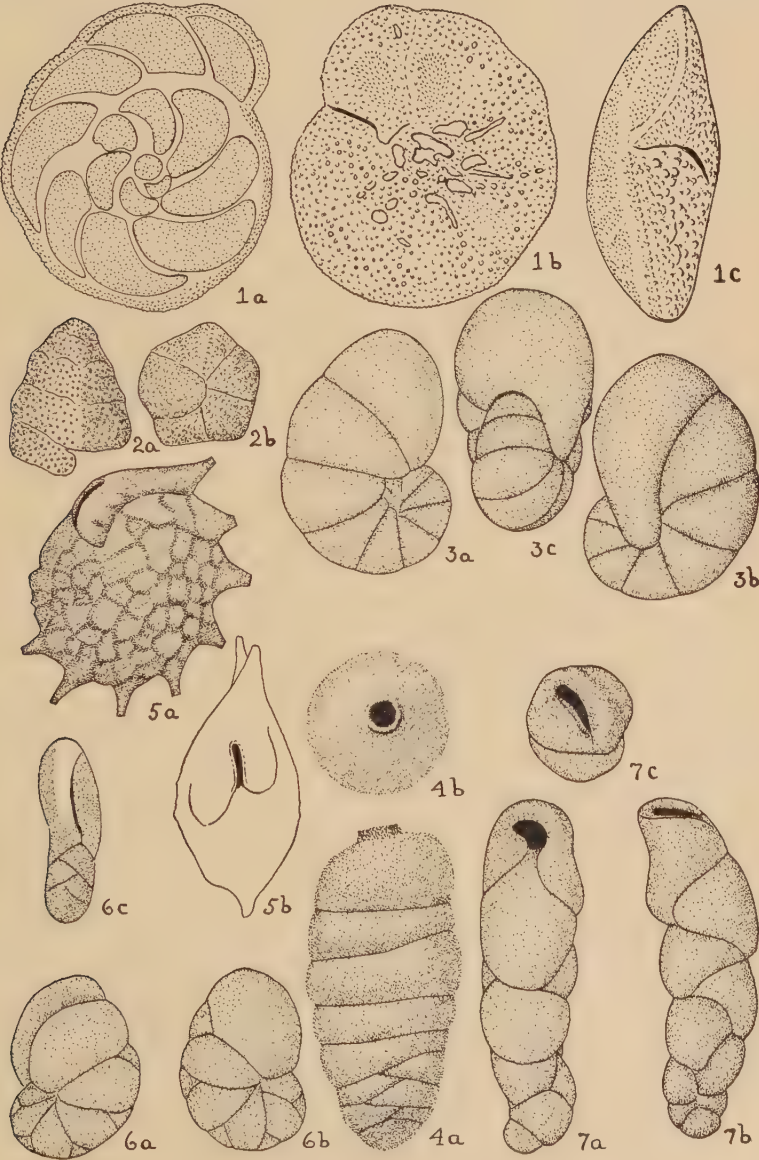
PLATE 6

- FIGS. 1 *a, b.* *Haplophragmoides advena* Cushman, n. sp. X 35.
a, side view; *b*, apertural view.
- FIGS. 2 *a, b.* *Haplophragmoides columbiensis* Cushman, n. sp. X 35.
a, side view; *b*, apertural view.
- FIGS. 3 *a-c.* *Trochammina pacifica* Cushman, n. sp. X 66.
a, dorsal view; *b*, ventral view; *c*, peripheral view.
- FIGS. 4 *a, b.* *Trochammina charlottensis* Cushman, n. sp. X 66.
a, dorsal view; *b*, ventral view.
- FIGS. 5 *a, b.* *Buliminella elegantissima* (d'Orbigny). X 66.
a, dorsal view; *b*, ventral view.
- FIGS. 6, 7. *Cassidulina charlottensis* Cushman, n. sp. X 35.
a, dorsal view; *b*, ventral view.
- FIG. 8. *Lagena orbignyana* (Seguenza). X 66.
 Front view.
- FIG. 9. *Polymorphina charlottensis* Cushman, n. sp. X 25.
 Front view.
- FIG. 10. *Spirillina spinigera* Chapman, var. *reducta* Cushman, n.
 var. X 35.
- FIGS. 11 *a, b*, 12. *Discorbis ornatissima* Cushman, n. sp. X 35.
 11 *a*, dorsal view; 11 *b*, ventral view; 12, peripheral
 view of the plastogamic pair.
- FIGS. 13 *a-c.* *Discorbis columbiensis* Cushman, n. sp. X 66.
a, dorsal view; *b*, ventral view; *c*, peripheral view.

PLATE 7

- FIGS. 1 *a-c.* *Pulvinulina columbiensis* Cushman, n. sp. X 25.
a, dorsal view; *b*, ventral view; *c*, peripheral view.
- FIGS. 2 *a, b.* *Discorbis charlottensis* Cushman, n. sp. X 125.
a, front view; *b*, ventral view.
- FIGS. 3 *a-c.* *Nonionina auris* (d'Orbigny). X 66.
a, dorsal view; *b*, ventral view; *c*, peripheral view.
- FIGS. 4 *a, b.* *Siphogenerina hughesi* Cushman, n. sp. X 35.
a, front view; *b*, apertural view.
- FIGS. 5 *a, b.* *Cassidulina elegantissima* Cushman, n. sp. X 30.
a, front view; *b*, apertural view.
- FIGS. 6 *a-c.* *Cassidulina orientale* Cushman, n. sp. X 66.
a, dorsal view; *b*, ventral view; *c*, apertural view.
- FIGS. 7 *a-c.* *Cassidulina parkeriana* H. B. Brady. X 50.
a, b, side views; *c*, apertural view.





12. FORAMINIFERA AS AN ORIGINAL SOURCE OF PETROLEUM

By JOSEPH A. CUSHMAN

There have been a very few suggestions made by palaeontologists working with petroleum problems that the foraminifera might be one of the sources of petroleum. This has been largely due to the fact that foraminifera are closely associated with oil bearing strata in many of the Tertiary and Cretaceous oil fields in various parts of the world. They also occur abundantly in the Subcarboniferous. In the Cretaceous and Tertiary particularly the forms found are reasonably closely allied to recent genera, and something may be definitely said about conditions in comparison with the present day ocean.

Very little has been done along the line of study of the living forms. However, I had an opportunity at the Tortugas Laboratory of the Carnegie Institution to study living tropical forms allied to such forms as occur in the Tertiary and Upper Cretaceous. One of the interesting results of this study was that the living protoplasm of many foraminifera, if not all, contain a greater or less amount of actual oil globules, usually of a yellowish color. In some genera and species these seem to be much more abundant than in others, and the resulting accumulation, if buried under favorable conditions, might conceivably produce a considerable amount of material, which later might be transposed into petroleum, or at least its early stages.

Another source, in connection with the foraminifera, is that many of the species, especially in tropical regions, have associated with them commensal algae, which are of low types, and in themselves might contribute materially to the source of material, which later might become petroleum.

A study of such living forms, especially in relation to their oil content, might prove very interesting from the point of view of their possibility as one of the original sources of petroleum.

RECENT LITERATURE ON THE FORAMINIFERA

Below are given some of the more recent works on the foraminifera that have come to hand.

Vaughan, T. W.

American and European Tertiary Larger Foraminifera.

(Bull. Geol. Soc. America, vol. 35, No. 4, 1924, pp. 785-822, pls. 30-36, text figures 1-6.) *Washington.*

A preliminary paper to a more comprehensive one on these larger forms. Several changes in the generic nomenclature are made, a new subgenus of *Lepidocyclina*-*Poly-lepidina* is described, as well as five new species of various genera.

Applin, E. R., Ellisor, A. E., and Kniker, H. T.

Subsurface Stratigraphy of the Coastal Plain of Texas and Louisiana.

(Bull. Amer. Assoc. Petrol. Geol., vol. 9, No. 1, 1925, pp. 79-122, pl. 3.) *Chicago.*

The Tertiary stratigraphy of this region is discussed at length, the faunal zones based on the small foraminifera which are found to be of great value. Mrs. Applin describes six new species and varieties which are figured.

Ozawa, Y.

On the Classification of Fusulinidae.

(Journ. Coll. Sci. Imper. Univ. Tokyo, vol. 45, Art. 4, 1925, pp. 1-26, pls. 1-4.) *Tokio.*

An important work for this family, giving keys to the subfamilies and genera, and discussing structure and phylogenetic relations. Many excellent figures are given and a new genus, *Staffella*, is described.

Yabe, H., and Hanzawa, S.

A Geological Problem concerning the Raised Coral-Reefs of the Riukiu Islands and Taiwan; A Consideration Based on the Fossil Foraminifera Faunas Contained in the Raised Coral-Reef Formation and the Youngest Deposits Underlying It.

(Sci. Rep. Tohoku Imper. Univ., ser. 2 [Geol.], vol. 7, No. 2, 1925, pp. 29-56 [1-28], pls. 5-10, [1-6].) *Tohoku.*

The relations of the foraminifera in the raised reefs to other known living faunas of the Indo-Pacific are given, and interpretations given. Many excellent figures from photographs are given. A full discussion is given of several species. There is one new variety of *Calcarina*.

Cushman, J. A.

An Eocene Fauna from the Moctezuma River, Mexico.

(Bull. Amer. Assoc. Petrol. Geol., vol. 9, No. 2, 1925, pp. 298-303, pls. 6-8.) Chicago.

Both the foraminifera and ostracoda of this Eocene deposit are described and figured. Five new species and one new variety of foraminifera are described, and three new species of ostracods.

Koch, R.

Die jungtertiäre Foraminiferenfauna von Kabu (Res. Surabaja, Java).

(Ber. Schweizerischen Paläontologischen Gesellschaft, vol. 18, No. 2, 1923, pp. 342-361, 11 text figures.) Basel.

There are one hundred and seven species noted from this late Tertiary of Java. There are ten text figures illustrating the newly described forms, of which three are new species, five new varieties, and one unnamed *Globigerina*.

Koch, R.

Eine jungtertiäre Foraminiferenfauna aus Ost-Seran.

(Ber. Schweizerischen Paläontologischen Gesellschaft, vol. 19, No. 1, 1925, pp. 207-213, figs. 1-7 [in text].) Basel.

Eighty-five species and varieties are listed from this Pliocene material of which six are described and figured as new.

Cushman, J. A.

The genera *Pseudotextularia* and *Guembelina*.

(Journ. Washington Acad. Sci., vol. 15, 1925, pp. 133, 134.) Washington.

Notes on these two Upper Cretaceous genera are given, and the relations of certain of the Mexican species to those of Europe.

CONTRIBUTIONS FROM THE CUSHMAN LABORATORY FOR FORAMINIFERAL RESEARCH

VOLUME 1, PART 3, OCTOBER 1925

13. NOTES ON THE GENUS CASSIDULINA

By JOSEPH A. CUSHMAN

While Mr. Donald D. Hughes and I were studying species of *Cassidulina* here at the laboratory, it became necessary to consult the original references of all the species of the genus. These references are all in my library here. As this work was of great use in the study of these species, it is here presented in outline for the guidance of others. There is often such a discrepancy between the figures given by later authors and the original type figure that the original must needs be seen and studied to determine what is meant by the author himself. It is also very valuable to know the type region of the species. Recent specimens referred to species described as fossils are often found to be different when type material is available. The species are here grouped by geologic periods, and the recent species by regions. Only the original reference is given with a copy of the type figure, and no attempt is here made to give a complete synonymy.

Genus *CASSIDULINA* d'Orbigny, 1826

Cassidulina d'Orbigny (type, *C. laevigata* d'Orbigny), Ann. Sci. Nat., vol. 7, 1826, p. 282.

Burseolina Seguenza, Atti. Accad. Lincei, ser. 3, vol. 6, 1880, p. 138.

Test complex, at least the early portion coiled, the chambers arranged biserially, alternating on the sides of the axis of coiling, chambers usually extending to the umbilicus on the sides, in some species the later portion of the test uncoiling; wall calcareous, perforate, usually smooth and without ornamentation; chambers numerous, the sutures usually distinct; aperture looplike, modified in breadth and length in the different species.

The species are widely distributed in the present ocean, usually in fairly deep or cool water. The species seem to be fewer as

they go back into the geologic formations. Although there are records from the Cretaceous, the genus is most abundant from Miocene time to the present.

GENOTYPE

Cassidulina laevigata d'Orbigny, Ann. Sci. Nat., vol. 7, 1826, p. 282, pl. 15, figs. 4, 5.

There is unfortunately no type locality for this species as it was described from ship's ballast, the source of which is unknown. (Pl. 8, figs. 1, 2.)

SPECIES, WITH TYPES FROM THE EASTERN ATLANTIC

Cassidulina bradyi Norman, in Wright, Proc. Belfast Nat. Field Club, 1880, Appendix, p. 152.

The first actual figures are given by Brady in the *Challenger* Report, pl. 54, figs. 6-10. Of these, figs. 6-9 are from *Porcupine* station 3, off Ireland; fig. 10 probably from a Pacific specimen not this species. (Pl. 8, figs. 3-5.) Norman's originals were from "Estuarine Clay," at Limarady Junction, Northeast Ireland.

C. bradyi Norman, var. *stenostegica* Goës, Kongl. Svensk. Vet. Akad. Handl., vol. 25, No. 9, 1894, p. 44, pl. 8, fig. 427.

Types from Baltic Sea and coast of Norway, 180-360 meters. (Pl. 8, fig. 6.)

C. obtusa Williamson, Recent British Foraminifera, 1858, p. 69, pl. 6, figs. 143, 144.

Types from Shetland (abundant), Fowey, Bixham, Hunde Island, Davis Strait. (Pl. 8, figs. 7, 8.)

SPECIES, WITH TYPES FROM THE WESTERN ATLANTIC

Cassidulina braziliensis Cushman, Bull. 104, U. S. Nat. Mus., pt. 3, 1922, p. 130, pl. 25, figs. 4, 5.

Types from off the coast of Brazil, 417 fathoms. (Pl. 8, figs. 9, 10.)

C. laevigata d'Orbigny, var. *carinata* Cushman, Bull. 104, U. S. Nat. Mus., pt. 3, 1922, p. 124, pl. 25, figs. 6, 7.

Types from off Ragged Key, Florida, 75 fathoms. (Pl. 8, figs. 11, 12.)

C. mexicana Cushman, Bull. 104, U. S. Nat. Mus., pt. 3, 1922, p. 131, pl. 24, fig. 5.

Types from off Bell, Fowey Rocks, Florida, 22 fathoms. (Pl. 8, fig. 13.)

SPECIES, WITH TYPES FROM THE MEDITERRANEAN

Cassidulina bradyi Norman, var. *elongata* Sidebottom, Mem. Proc. Manchester Lit. Philos. Soc., vol. 49, No. 5, 1905, p. 17, pl. 3, fig. 11.

Types from off the Island of Delos, 8-14 fathoms. (Pl. 8, figs. 14, 15.)

SPECIES, WITH TYPES FROM THE PACIFIC

Cassidulina bradyi Norman, var. *attenuata* Chapman, Journ. Linn. Soc. Zool., vol. 30, 1910, p. 406, pl. 54, fig. 4.

Types from off Funafuti, 2400 fathoms. (Pl. 8, fig. 16.)

C. charlottensis Cushman, Contrib. Cushman Lab. Foram. Research, vol. 1, pt. 2, 1925, p. 41, pl. 6, figs. 6, 7.

Types from Queen Charlotte Sound, British Columbia, 20-25 fathoms. (Pl. 8, figs. 17, 18.)

C. clavata H. B. Brady, Rep. Voy. *Challenger*, Zoology, vol. 9, 1884, p. 432, pl. 113, fig. 9.

Types from Nares Harbor, Admiralty Islands, 17 fathoms. (Pl. 8, fig. 19.)

C. decorata Sidebottom, Journ. Quekett Micr. Club, ser. 2, vol. 11, 1910, p. 107, pl. 4, figs. 2a-c.

Types from Southwest Pacific, 19°04'S.; 179°43'E.; 1,050 fathoms. (Pl. 8, figs. 20-22.)

C. elegans Sidebottom, Journ. Quekett Micr. Club, ser. 2, vol. 11, 1910, p. 106, pl. 4, figs. 1a-c.

Types from Southwest Pacific, 19°04'S.; 179°43'E.; 1,050 fathoms. (Pl. 8, figs. 23-25.)

C. elegantissima Cushman, Contrib. Cushman Lab. Foram. Research, vol. 1, pt. 2, 1925, p. 37, pl. 7, figs. 5a, b.

Types from North Pacific, 1,997 fathoms, between Midway Island and Guam. (Pl. 8, figs. 26, 27.)

C. orientale Cushman, Contrib. Cushman Lab. Foram. Research, vol. 1, pt. 2, 1925, p. 37, pl. 7, figs. 6a-c.

Types from south of Japan, 2,080 fathoms. (Pl. 8, figs. 28, 29.)

C. pacifica Cushman, new name. See note under *C. calabra* (Seguenza) below. (Pl. 9, figs. 14-16.)

C. parkeriana H. B. Brady, Quart. Journ. Micr. Sci., vol. 21, 1881, p. 59; Rep. Voy. *Challenger*, Zoology, vol. 9, 1884, p. 432, pl. 54, figs. 11-16.

Types from "amongst the Islands on the west coast of Patagonia", 45-175 fathoms. (Pl. 8, figs. 30-33.)

C. pulchella d'Orbigny, Voy. Amér. Mérid., vol. 5, pt. 5, "Foraminifères", 1839, p. 57, pl. 8, figs. 1-3.

Types from the coast of Peru. (Pl. 8, figs. 34-36.)

SPECIES, WITH TYPES FROM THE ANTARCTIC

Cassidulina crassa d'Orbigny, Voy. Amér. Mérid., vol. 5, pt. 5, "Foraminifères," 1839, p. 56, pl. 7, figs. 18-20.

Types from Falkland Islands and Cape Horn. (Pl. 8, figs. 37-39.)

C. laevigata d'Orbigny, var. *tumida* Heron-Allen and Earland, Brit. Antarctic Exped., Zool., vol. 6, 1922, p. 138, pl. 5, figs. 36-38.

Types from off Three Kings Island, New Zealand, 90-300 fathoms. (Pl. 8, figs. 40-42.)

C. pupa d'Orbigny, Voy. Amér. Mérid., vol. 5, pt. 5, "Foraminifères," 1839, p. 57, pl. 7, figs. 21-23.

Types from Falkland Islands. = *Ehrenbergina*.

C. subglobosa H. B. Brady, var. *tuberculata* Heron-Allen and Earland, Brit. Antarctic Exped., Zool., vol. 6, 1922, p. 138, pl. 4, figs. 36-38.

Types from the Antarctic, 69°15'S.; 58 E.; 245 fathoms. (Pl. 8, figs. 43-45.)

SPECIES, WITH TYPE LOCALITY NOT DESIGNATED

Cassidulina subglobosa H. B. Brady, Quart. Journ. Micr. Sci., vol. 21, 1881, p. 60; Rep. Voy. *Challenger*, Zoology, vol. 9, 1884, p. 430, pl. 54, figs. 17a-c. (Pl. 8, figs. 48-50.)

SPECIES, WITH TYPES FROM PLEISTOCENE

Cassidulina sicula Seguenza, Atti Accad. Gioenia Sci. Nat., ser. 2, vol. 18, 1862, p. 111, pl. 1, figs. 7, 7a.

Types from Catania, Sicily. (Pl. 8, figs. 46, 47.)

C. subglobosa H. B. Brady, var. *quadrata* Cushman and Hughes, Contrib. Cushman Lab. Foram. Research, vol. 1, pt. 1, 1925, p. 15, pl. 2, figs. 7a-c.

Types from Lomita Quarry, Palos Verdes Hills, Los Angeles Co., California. (Pl. 9, figs. 1, 2.)

C. translucens Cushman and Hughes, Contrib. Cushman Lab. Foram. Research, vol. 1, pt. 1, 1925, p. 15, pl. 2, figs. 5a-c.

Types from Lomita Quarry, Palos Verdes Hills, Los Angeles Co., California. (Pl. 9, figs. 3, 4.)

SPECIES, WITH TYPES FROM PLIOCENE

Cassidulina californica Cushman and Hughes, Contrib. Cushman Lab. Foram. Research, vol. 1, pt. 1, 1925, p. 12, pl. 2, figs. 1a-c.

Types from Timms Point, San Pedro, California. (Pl. 9, figs. 5, 6.)

C. corbyi Cushman and Hughes, Contrib. Cushman Lab. Foram. Research, vol. 1, pt. 1, 1925, p. 14, pl. 2, figs. 3a, b.

Types from Ventura Co., California. (Pl. 9, figs. 9, 10.)

C. limbata Cushman and Hughes, Contrib. Cushman Lab. Foram. Research, vol. 1, pt. 1, 1925, p. 12, pl. 2, figs. 2a-c.

Types from Timms Point, San Pedro, California. (Pl. 9, figs. 7, 8.)

C. murrhyna (Schwager), *Sphaeroidina murrhyna* Schwager, *Novara-Exped.*, Geol. Theil, vol. 2, 1866, p. 250, pl. 7, fig. 97.

Types from Kar Nicobar. (Pl. 9, fig. 11.)

C. tortuosa Cushman and Hughes, Contrib. Cushman Lab. Foram. Research, vol. 1, pt. 1, 1925, p. 14, pl. 2, figs. 4a-c.

Types from Timms Point, San Pedro, California. (Pl. 9, figs. 12, 13.)

SPECIES, WITH TYPES FROM MIOCENE

Cassidulina alata Seguenza, Atti R. Accad. Lincei, ser. 3, vol. 6, 1880, p. 65, pl. 7, fig. 5.

Types from Reggio, Calabria, Italy. (Pl. 9, figs. 17, 18.)

C. calabra (Seguenza). *Burseolina calabra* Seguenza, Atti R. Accad. Lincei, ser. 3, vol. 6, 1880, p. 138, pl. 13, figs. 7a, b.

Types from Reggio, Calabria, Italy.

The original figure given by Seguenza does not at all resemble a *Cassidulina*. Brady had type material sent him for examination, and placed them under *Cassidulina* although Seguenza placed his genus *Burseolina* between *Pullenia* and *Nonionina*, and his figures certainly resemble these. Brady refers material from the South Pacific to this species of Seguenza, and figures what is certainly a *Cassidulina* from this region. There are numerous other records based on Brady's figure in the *Challenger* Report, and these are all from the Pacific or Antarctic. It would seem, therefore, that the Pacific species is different from that of Seguenza, and might deserve a new name, which we will propose as *Cassidulina pacifica* Cushman, new name. (Pl. 9, figs. 14-16.) Brady's *Challenger* specimen figured, which has a different shape and certainly a very different aperture from that figured and described by Seguenza, may be taken as the type.

C. globulosa Egger, Neues Jahrb. für Min., 1857, p. 296, pl. 11, figs. 4-7.

Types from Bavaria. =Globigerinidae.

C. oblonga Reuss, Denkschr. Akad. Wiss. Wien, vol. 1, 1850, p. 376, pl. 48, figs. 5, 6.

Types from Austria. (Pl. 9, figs. 19-22.)

C. punctata Reuss, Denkschr. Akad. Wiss. Wien, vol. 1, 1850, p. 376, pl. 48, fig. 4.

Types from Austria. (Pl. 9, figs. 23, 24.)

SPECIES, WITH TYPES FROM OLIGOCENE

Cassidulina margareta Karrer, Abhandl. k. k. geol. Reichs., vol. 9, 1877, p. 386, pl. 16b, fig. 52.

Types from Baden, Austria. (Pl. 9, figs. 29, 30.)

SPECIES, WITH TYPES FROM EOCENE

Cassidulina globosa Hantken, A. magy. kir. földt. int. evkoyve, vol. 4, 1875 (1876), p. 54, pl. 16, fig. 2.

Types from Austria Hungary. (Pl. 9, figs. 25, 26.)

C. inexculta Franzenau, Math. Naturw. Bericht. aus Ungarn, vol. 7, 1889, p. 66, pl. 3, fig. 2.

Types from near Budapest. (Pl. 9, figs. 27, 28.) This very much resembles Seguenza's *Burseolina*.

EXPLANATION OF PLATES

PLATE 8

- FIGS. 1, 2. *Cassidulina laevigata* d'Orbigny. (After d'Orbigny, 1826.)
FIGS. 3-5. *Cassidulina bradyi* Norman. (After H. B. Brady, 1884.)
FIG. 6. *Cassidulina bradyi* Norman, var. *stenostegica* Goës. (After Goës, 1894.)
FIGS. 7, 8. *Cassidulina obtusa* Williamson. (After Williamson, 1858.)
FIGS. 9, 10. *Cassidulina braziliensis* Cushman. (After Cushman, 1922.)
FIGS. 11, 12. *Cassidulina laevigata* d'Orbigny, var. *carinata* Cushman. (After Cushman, 1922.)
FIG. 13. *Cassidulina mexicana* Cushman. (After Cushman, 1922.)
FIGS. 14, 15. *Cassidulina bradyi* Norman, var. *elongata* Sidebottom. (After Sidebottom, 1905.)
FIG. 16. *Cassidulina bradyi* Norman, var. *attenuata* Chapman. (After Chapman, 1910.)
FIGS. 17, 18. *Cassidulina charlottensis* Cushman. (After Cushman, 1925.)
FIG. 19. *Cassidulina clavata* H. B. Brady. (After H. B. Brady, 1884.)
FIGS. 20-22. *Cassidulina decorata* Sidebottom. (After Sidebottom, 1910.)
FIGS. 23-25. *Cassidulina elegans* Sidebottom. (After Sidebottom, 1910.)
FIGS. 26, 27. *Cassidulina elegantissima* Cushman. (After Cushman, 1925.)
FIGS. 28, 29. *Cassidulina orientale* Cushman. (After Cushman, 1925.)
FIGS. 30-33. *Cassidulina parkeriana* H. B. Brady. (After H. B. Brady, 1884.)
FIGS. 34-36. *Cassidulina pulchella* d'Orbigny. (After d'Orbigny, 1839.)
FIGS. 37-39. *Cassidulina crassa* d'Orbigny. (After d'Orbigny, 1839.)
FIGS. 40-42. *Cassidulina laevigata* d'Orbigny, var. *tumida* Heron-Allen and Earland. (After Heron-Allen and Earland, 1922.)
FIGS. 43-45. *Cassidulina subglobosa* H. B. Brady, var. *tuberculata* Heron-Allen and Earland. (After Heron-Allen and Earland, 1922.)
FIGS. 46, 47. *Cassidulina sicula* Seguenza. (After Seguenza, 1862.)
FIGS. 48-50. *Cassidulina subglobosa* H. B. Brady. (After H. B. Brady, 1884.)

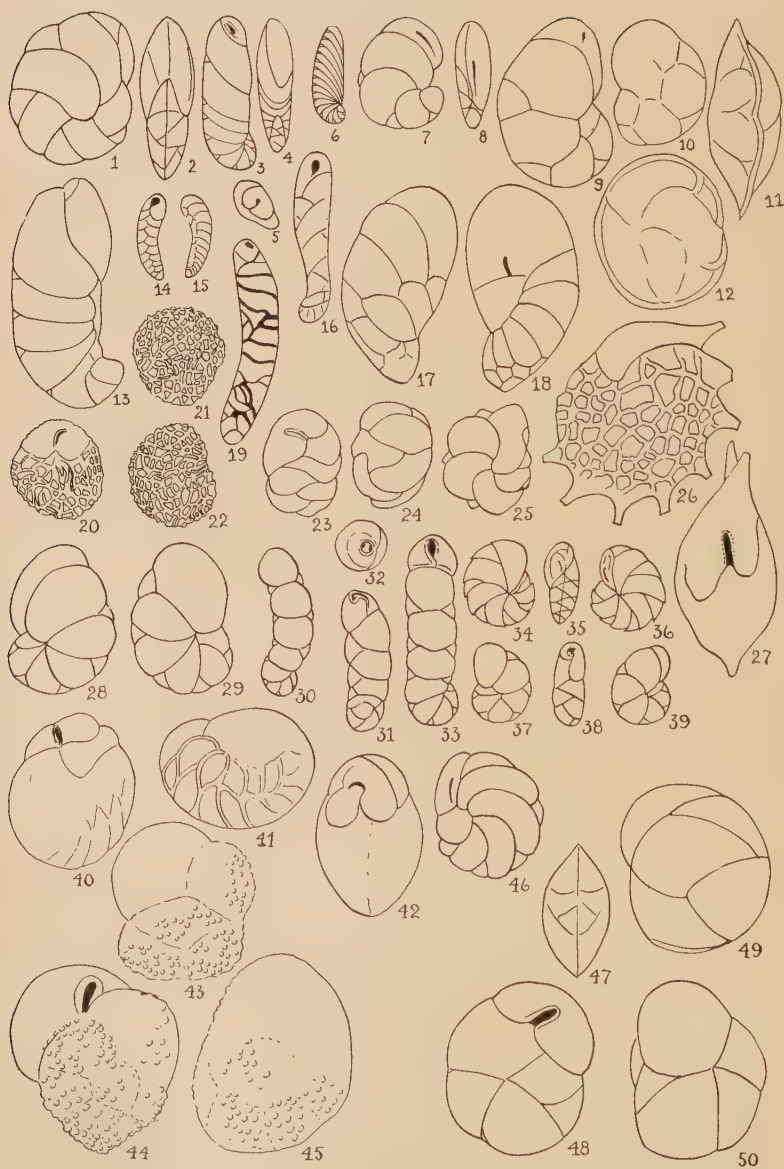
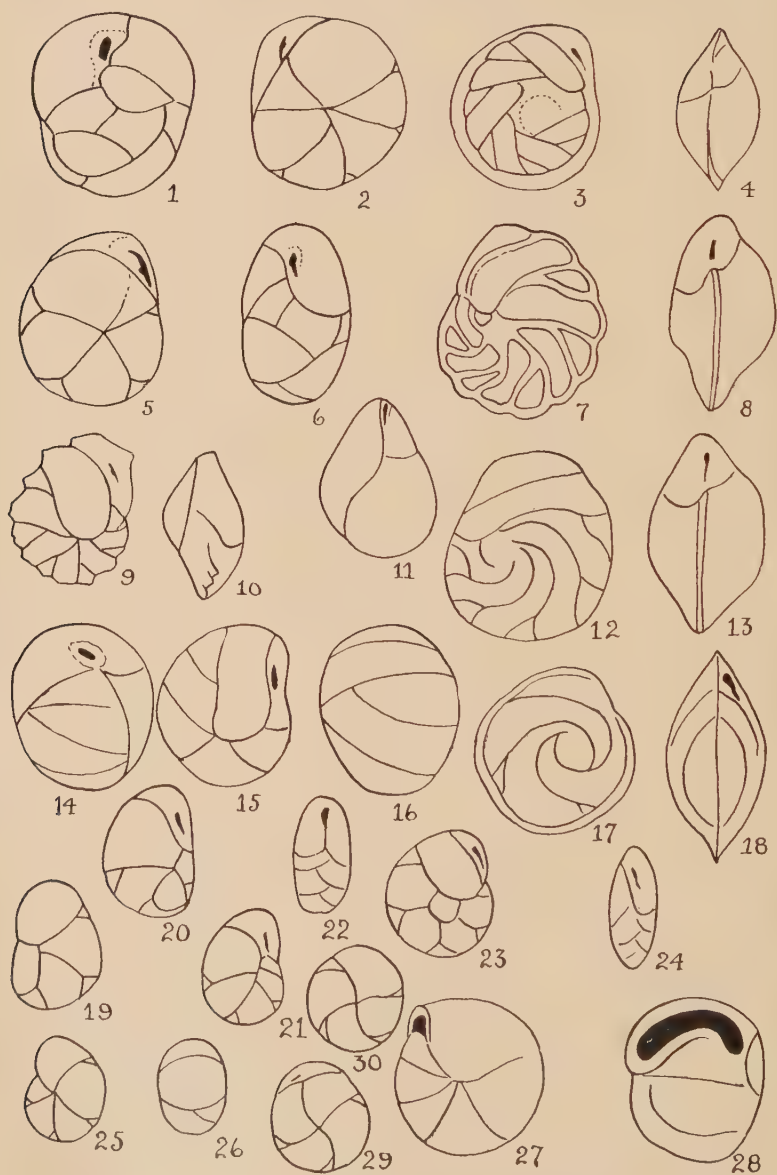


PLATE 9

- FIGS. 1, 2. *Cassidulina subglobosa* H. B. Brady, var. *quadrata* Cushman and Hughes. (After Cushman and Hughes, 1925.)
- FIGS. 3, 4. *Cassidulina translucens* Cushman and Hughes. (After Cushman and Hughes, 1925.)
- FIGS. 5, 6. *Cassidulina californica* Cushman and Hughes. (After Cushman and Hughes, 1925.)
- FIGS. 7, 8. *Cassidulina limbata* Cushman and Hughes. (After Cushman and Hughes, 1925.)
- FIGS. 9, 10. *Cassidulina corbyi* Cushman and Hughes. (After Cushman and Hughes, 1925.)
- FIG. 11. *Cassidulina murrhyna* (Schwager). (After Schwager, 1866.)
- FIGS. 12, 13. *Cassidulina tortuosa* Cushman and Hughes. (After Cushman and Hughes, 1925.)
- FIGS. 14-16. *Cassidulina pacifica* Cushman, new name. (After H. B. Brady, 1884.)
- FIGS. 17, 18. *Cassidulina alata* Seguenza. (After Seguenza, 1880.)
- FIGS. 19-22. *Cassidulina oblonga* Reuss. (After Reuss, 1850.)
- FIGS. 23, 24. *Cassidulina punctata* Reuss. (After Reuss, 1850.)
- FIGS. 25, 26. *Cassidulina globosa* Hantken. (After Hantken, 1876.)
- FIGS. 27, 28. *Cassidulina inexculta* Franzénau. (After Franzénau, 1889.)
- FIGS. 29, 30. *Cassidulina margareta* Karrer. (After Karrer, 1877.)



14. MEXICAN SPECIES OF MARGINULINA

By JOSEPH A. CUSHMAN

There are a few species of *Marginulina* in the Oligocene and Eocene of the Coastal Plain of Mexico, which are of especial interest in that they do not as a rule occur together, but are distinctive of rather definite horizons. A study of these shows that two of them at least are new, and the other has interesting relationships to European species. They may be classed as follows:

MARGINULINA MEXICANA Cushman, n. sp.Plate 10, figs. 1 *a*, *b*

Test elongate, compressed, especially in the earlier portion, early chambers close coiled, but soon becoming uncoiled, and the last two or three uniserial; chambers indistinct in the earlier portion, later ones becoming more distinct, inflated; sutures depressed; surface ornamented with a few sharp longitudinal costae, 10-12 in number, the last-formed chamber sometimes with more; aperture with a definite constricted neck.

Length up to 1 mm.

Type specimen (U. S. N. M. Coll. No. 353679), from San Rafael formation, Huasteca R. R., km. post 9, 0.8 kms. east of Big Cut, Mexico, collected by T. Wayland Vaughan.

MARGINULINA PULCHRA Cushman, n. sp.Plate 10, figs. 2 *a*, *b*

Test elongate, tapering, consisting of 7 or 8 chambers, the earliest very slightly compressed in the microspheric form, subglobular in the megalospheric, the first 3 or 4 chambers in an arcuate curve, later ones straight, subglobular in form; sutures deeply depressed; wall ornamented with high, thin longitudinal costae, 13-15 in the later chambers, the basal angle of each costa sometimes produced and spinelike; aperture with a short slender cylindrical neck with annular costae and a slight lip.

Length up to 1 mm.

Type specimen (U. S. N. M. Coll. No. 353680), from southwest slope of Cuesta Blanca, near Zacamixtle, Vera Cruz, Mexico, collected by T. Wayland Vaughan.

This is very distinct from the preceding species in the more

inflated, less compressed form, the larger number of costae, and much more distinct chambers. It is more tapering and the costae different from the figures Halkyard gives of *Marginulina brehmi* (Reuss), from the Upper Eocene of Biarritz (Mem. Proc. Manchester Lit. Philos. Soc., vol. 62, pt. 2, 1919, p. 85, pl. 5, figs. 3, 4), but has a distinct resemblance.

MARGINULINA SUBBULLATA Hantken

Plate 10, figs. 3 *a*, *b*

Marginulina subbullata HANTKEN, Amagy. kir. földt. int. évkön, vol. 4, 1875 (1876), p. 39, pl. 4, figs. 9, 10; pl. 5, fig. 9.

Test subcylindrical, the initial end broadly rounded, the first three chambers arranged in a loose coil, later two or three uniserial; chambers few, inflated; sutures distinct and depressed; wall smooth and polished; apertural end produced with a small tapering neck and radiate aperture.

Length up to 0.75 mm.

This few-chambered inflated form very closely resembles that described and figured by Hantken from the Upper Eocene of Central Europe. It also somewhat resembles *Marginulina pachygaster* described by Gümbel from the Upper Eocene of Bavaria, but the chambers of the Mexican specimens are identical with those of Hantken's species whereas those of Gümbel are more elongate. The early chambers also are identical with Hantken's figures.

The Mexican specimens are from Rio Buena Vista, 2 kms. in a straight line above its confluence with Rio Tuxpan, Vera Cruz, Mexico, collected by T. Wayland Vaughan.

15. NOTES ON THE GENUS TRITAXILINA

By JOSEPH A. CUSHMAN

In 1911 I erected the genus *Tritaxilina* for the species described by H. B. Brady as *Tritaxia caperata* (earlier *Clavulina caperata*). The form of the test, in general fusiform, with an early triserial arrangement of the chambers, later biserial and finally uniserial, as well as the labyrinthic form of the interior, all serve to separate it from *Tritaxia*. The Atlantic form was separated in 1922, and a fossil species is here described from the Upper Eocene of Mexico.

Genus TRITAXILINA Cushman, 1911

Clavulina (part) H. B. BRADY, Quart. Journ. Micr. Sci., vol. 21, 1881, p. 54.

Tritaxia (part) H. B. BRADY, Rep. Voy. *Challenger*, Zoology, vol. 9, 1884, p. 390.

Tritaxilina CUSHMAN (type, *T. caperata* (H. B. Brady)), Bull. 71, U. S. Nat. Mus., pt. 2, 1911, p. 71; Bull. 104, U. S. Nat. Mus., pt. 3, 1922, p. 79.

Test in its early development triserial, later becoming biserial, and in the adult typically uniserial; chambers numerous, distinct, interior labyrinthic; wall arenaceous; aperture in the triserial portion elongate with a valvular lip, at the edge of the inner side of the chamber, in the adult central, terminal, usually with a series of peripheral teeth projecting in and partially closing the opening.

The genus now includes the type species from the tropical Pacific, a recent species from the tropical Atlantic, and a fossil species from the Upper Eocene of Mexico.

TRITAXILINA CAPERATA (H. B. Brady)

Clavulina caperata H. B. BRADY, Quart. Journ. Micr. Sci., vol. 21, 1881, p. 54.

Tritaxia caperata H. B. BRADY, Rep. Voy. *Challenger*, Zoology, vol. 9, 1884, p. 390, pl. 49, figs. 1, 2, 4-7 (not fig. 3).

Tritaxilina caperata CUSHMAN, Bull. 71, U. S. Nat. Mus., pt. 2, 1911, p. 71, figs. 112, 113 (in text); Bull. 100, U. S. Nat. Mus., vol. 4, 1921, p. 153, pl. 28, figs. 4 *a*, *b*.

Test fusiform, early portion triserial, roughly triangular in transverse section, the angles much rounded, later portion biserial or finally uniserial, circular in section, apical end somewhat pointed, apertural end truncate or broadly rounded; chambers numerous; the wall thick, of fine arenaceous material with pore canals, interior labyrinthic, outer surface of the test with a wrinkled appearance due to the thickening of the chamber wall just above the sutures; sutures distinct, depressed; aperture in the young as in *Verneuilina*, in the adult becoming terminal and central with a border of inwardly projecting teeth.

Length up to 2.25 mm.

The type specimens were from a *Challenger* station off the Philippines in 95 fathoms. In addition Brady had material from off Kandavu, Fiji Islands in 250 fathoms. I recorded the species from *Albatross* station 4781 in 482 fathoms in the North Pacific, and from five Philippine stations at depths ranging from 80 to 340 fathoms. Nothing further is known of the species.

TRITAXILINA ATLANTICA Cushman

Tritaxia caperata H. B. BRADY (part), Rep. Voy. *Challenger*, Zoology, vol. 9, 1884, p. 390, pl. 49, figs. 3 *a*, *b* (not figs. 1, 2, 4-7).

Tritaxilina caperata (H. B. BRADY), var. *atlantica* CUSHMAN, Bull. 104, U. S. Nat. Mus., pt. 3, 1922, p. 79, pl. 15, figs. 1, 2.

Test rapidly increasing in diameter from the subacute base, the sides for the most part nearly parallel, slightly contracted toward the apertural end, early portion triserial, roughly triangular in transverse section, angles rounded; chambers fairly distinct; sutures slightly depressed; wall arenaceous, light yellowish brown; aperture of the triserial and biserial portions very small, subcircular at the inner margin of the apertural face.

Maximum length 1.75 mm.

Type specimens were from *Albatross* station D2150 in 382 fathoms in the Caribbean Sea. Brady's records from *Challenger* stations 23, in 450 fathoms, and 24, in 390 fathoms, off the Leeward Islands, are in the same vicinity. From the *Challenger* material from station 23, figure 3 of plate 49 was drawn. It is typical *Tritaxilina atlantica*. Outside of its occurrence at these three closely adjacent stations nothing is known of this species, which cannot be mistaken for the one of the tropical Pacific.

TRITAXILINA MEXICANA Cushman, n. sp.

Plate 10, fig. 4

Test somewhat fusiform, the sides of the median portion nearly parallel, thence converging toward the truncate apertural end, early portion triserial, the biserial portion making up most of the test; chambers numerous, fairly distinct; wall arenaceous; sutures only slightly depressed; aperture rounded, fairly large, becoming somewhat terminal in the adult.

Length up to nearly 3 mm.

Type specimen (U. S. N. M. Coll. No. 353681), from Rio Buena Vista, just south of crossing of Alazan to Moyutla road, Vera Cruz, Mexico, collected by T. Wayland Vaughan.

This is the first occurrence of the genus in the fossil state. The Mexican species may well be the ancestral form of the other two as it holds the characters of both. The general form is somewhat intermediate, being more fusiform than the Atlantic species, but less elongate fusiform than the Pacific one. Its surface appearance is more like *T. atlantica*, the chambers not so indistinct but much less so than in *T. caperata*. The thickening of the basal portion of the chambers is also intermediate between the two. *Tritaxilina mexicana* is associated with species known from the Eocene of America and Europe.

One of the interesting things about *Tritaxilina* is its known distribution in the tropical Atlantic and Pacific, and in the Eocene of a tropical region. With it in all these regions is associated *Bigenerina pennatula* (Batsch) or a closely allied species. A similar form occurs in Mexico associated with *Tritaxilina mexicana*. *Bigenerina pennatula* is recorded from Albatross D2150, the type locality of *Tritaxilina atlantica*, and also from D5318 from a Philippine station from which *T. caperata* is recorded. The group represented by *Bigenerina pennatula* (Batsch) and *B. capreolus* (d'Orbigny) has a very interesting geologic history and recent distribution, and will be discussed in another paper.

16. EOCENE FORAMINIFERA FROM THE COCOA SAND OF ALABAMA

By JOSEPH A. CUSHMAN

The Cocoa sand, which occurs in its typical form at Cocoa Post Office, Alabama, contains an abundance of foraminifera. It is of Upper Eocene, Jackson, age, and has many species of foraminifera which are widely distributed in the Upper Eocene of the general Gulf Coastal Plain, extending through the Jackson of Texas into the Alazan and Tantoyuca formations of Mexico. Excellent material of this Upper Eocene of Cocoa Post Office was placed in my hands for study by Dr. R. S. Bassler of the U. S. National Museum. Some of the species are closely related to or identical with those of the Upper Eocene of Europe. A few of the species are described here.

BULIMINA JACKSONENSIS Cushman

Bulimina jacksonensis CUSHMAN, Contrib. Cushman Lab. Foram. Res., vol. 1, pt. 1, 1925, p. 6, pl. 1, figs. 6, 7.

This species already described from the Tantoyuca formation of the Upper Eocene of Mexico is abundant in the Upper Eocene of the United States, and occurs in the material from Cocoa Post Office.

NODOSARIA COCOAENSIS Cushman, n. sp.

Plate 10, figs. 5, 6

Test elongate, very slender, slightly curved, gradually tapering from the acute or spinose initial end, early portions with the sides straight, toward the apertural end with the chambers slightly inflated; chambers in the adult 11-14, in the very early portion only slightly longer than broad, becoming as much as $2\frac{1}{2}$ -3 times as long as broad in the last-formed ones; sutures very distinct, of clear shell material, but not depressed; wall very smooth, slightly glossy in well-preserved specimens; apertural end produced.

Maximum length 2.25 mm.; maximum breadth 0.20 mm.

Type specimen (U. S. N. M. Coll. No. 353682), from Cocoa Post Office, Alabama.

This species is allied to *Nodosaria filiformis* d'Orbigny, and other species. It is very close to Hantken's figure of *Dentalina consobrina* d'Orbigny from the Eocene of the *Clavulina szaboi* beds of Hungary, but the early portion is different. It is also close to the recent material figured by Flint from off the Coast of the United States as *Nodosaria filiformis*.

NODOSARIA LATEJUGATA Gümbel

Plate 10, fig. 7

Nodosaria latejugata GÜMBEL, Abh. kön. bay. Akad. Wiss. München, vol. 10, 1868 (1870), p. 619, pl. 1, fig. 32.—Hantken, A. magy. kir. földt. int. evkôn., vol. 4, 1875 (1876), p. 21, pl. 2, figs. 6 a-d.

Nodosaria budensis HANTKEN, l. c., p. 23, pl. 2, fig. 10; pl. 16, fig. 4.

Length of American specimens up to 8 mm.; breadth 0.5 mm.

Gümbel originally described this species from the Upper Eocene of Bavaria, and Hantken figures it from the Upper Eocene of Hungary. Our American Upper Eocene specimens are very similar except that the microspheric form also occurs. It belongs to the general *Nodosaria raphanus* group, which occurs in many species from the Cretaceous onward.

It occurs at Cocoa Post Office, Alabama.

NODOSARIA FISSICOSTATA (Gümbel)

Plate 10, fig. 8

Dentalina fissicostata GÜMBEL, Abh. kön. bay. Akad. Wiss. München, vol. 10, 1868 (1870), p. 626, pl. 1, fig. 46.—Hantken, A. magy. kir. földt. int. evkôn., vol. 4, 1875 (1876), p. 37, pl. 3, fig. 19.

Gümbel described this species from the Upper Eocene of Bavaria, and Hantken records it from the Eocene of Central

Europe and Italy with numerous localities. He gives as measurements, length 3-6 mm.; breadth of last chamber 0.6-1 mm. Our American specimens measure up to 6 mm. in length and 0.6 mm. in breadth. The specimens are easily broken, and complete specimens are rare.

It occurs at Cocoa Post Office, Alabama.

CRISTELLARIA GUTTICOSTATA (Gumbel), var. **COCOAENSIS** Cushman,
n. var.

Plate 10, fig. 11

This variety is very beautifully developed, the beading very prominent with a group of large beads in the umbilical area, in the adults having the last-formed suture often without beads and slightly depressed.

This variety occurs in the Cocoa sand while the typical form occurs in other parts of the Upper Eocene.

Type of variety (U. S. N. M. Coll. No. 353683), from Cocoa Post Office, Alabama.

MARGINULINA COCOAENSIS Cushman, n. sp.

Plate 10, figs. 9, 10

Test elongate, compressed, initial end composed of a few partially coiled chambers much compressed, later and major portions composed of 6-10 more rounded chambers; sutures fairly distinct, of clear shell material; ornamentation consisting of 9 or 11 lamellate costae running from the initial end to the base of the last-formed chamber in adults, the last chamber usually smooth in completely developed specimens, two of the costae forming keels on the compressed portion; aperture on the peripheral side of the apertural face, radiate, at the end of a distinct projection.

Maximum length 1.60 mm.; breadth 0.25 mm.

Type (U. S. N. M. Coll. No. 353684), from Cocoa Post Office, Alabama.

UVIGERINA JACKSONENSIS Cushman, n. sp.

Plate 10, fig. 13

Test large for the genus, stout, broadly fusiform, greatest width at the middle, periphery slightly lobulated; chambers few, inflated; sutures somewhat depressed, basal part of chamber not conspicuously overhanging, evenly curved; wall with coarse longitudinal costae, in the early portion usually limited to the individual chamber, in the later portion usually becoming con-

fluent with those of the chamber above and below, 18-22 costae in the complete circumference in the widest region; apertural end with a cylindrical neck of medium length and phialine lip.

Maximum length 0.90 mm.; breadth 0.45 mm.

Type specimen (U. S. N. M. Coll. No. 353685), from Cocoa Post Office, Alabama.

UVIGERINA COCOAENSIS Cushman, n. sp.

Plate 10, fig. 12

Test of medium size, elongate, fusiform, greatest width somewhat above the middle periphery very slightly lobulate; chambers rather few, inflated, evenly rounded; sutures slightly depressed; wall with coarse longitudinal costae, not usually confluent with those of adjacent chambers, becoming lower and less conspicuous in later chambers, last-formed chamber in the adult usually smooth, 12-16 costae in the complete circumference in the widest region; apertural end with a short cylindrical neck and phialine lip.

Maximum length 0.80 mm.; breadth 0.30-0.35 mm.

Type specimen (U. S. N. M. Coll. No. 353686), from Cocoa Post Office, Alabama.

This species is nearest to *U. jacksonensis*, but is somewhat smaller, more slender, and has fewer costae.

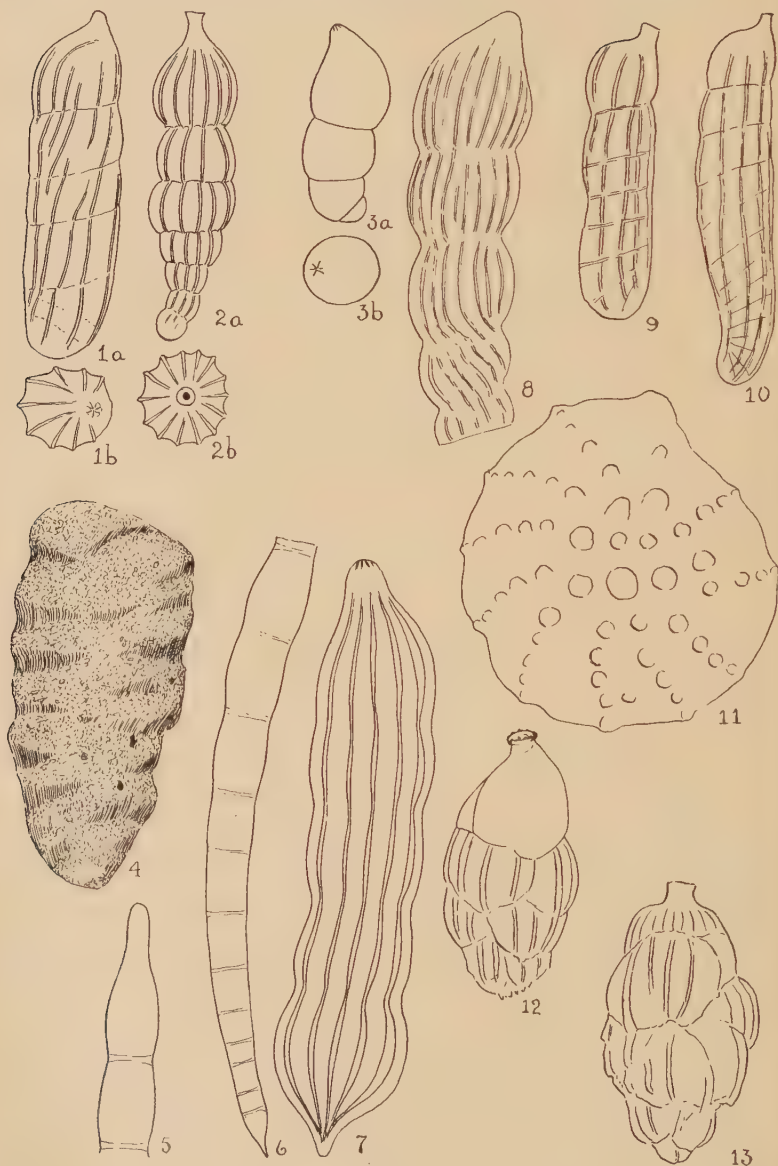
HANTKENINA ALABAMENSIS Cushman

Hantkenina alabamensis CUSHMAN, Proc. U. S. Nat. Mus., vol. 66, 1924, p. 3, pl. 1, figs. 1-6; pl. 2, fig. 5; Contrib. Cushman Lab. Foram. Research, vol. 1, pt. 1, 1925, p. 7, pl. 1, fig. 11.

This species was originally described from this material from Cocoa Post Office, Alabama, where it is abundant. It is known from the Upper Eocene of Texas, and the Upper Eocene (Alazan) of Mexico.

EXPLANATION OF PLATE 10

- FIGS. 1a, b. *Marginulina mexicana* Cushman, n. sp. a, front view; b, apertural view.
- FIGS. 2a, b. *Marginulina pulchra* Cushman, n. sp. a, front view; b, apertural view.
- FIGS. 3a, b. *Marginulina subbullata* Hantken. a, front view; b, apertural view.
- FIG. 4. *Tritaxilina mexicana* Cushman, n. sp.
- FIGS. 5, 6. *Nodosaria cocoaensis* Cushman, n. sp. 5, end of specimen, showing the apertural characters; 6, showing the initial end, apertural end broken.
- FIG. 7. *Nodosaria latejugata* Gümbel.
- FIG. 8. *Nodosaria fissicostata* (Gümbel).
- FIGS. 9, 10. *Marginulina cocoaensis* Cushman, n. sp. 9, megalospheric form; 10, microspheric form.
- FIG. 11. *Cristellaria gutticostata* (Gümbel), var. *cocoaensis* Cushman, n. var.
- FIG. 12. *Uvigerina cocoaensis* Cushman, n. sp.
- FIG. 13. *Uvigerina jacksonensis* Cushman, n. sp.



RECENT LITERATURE ON THE FORAMINIFERA

Below are given some of the more recent works on the foraminifera that have come to hand.

Yabe, H. and Hanzawa, S.

Nummulitic Rocks of the Islands of Amakusa (Kyushu, Japan).

Sci. Rep. Tohoku Imp. Univ., sec. ser. (Geol.), vol. 7, No. 3, 1925, pp. 73-82 (1-10), pls. 18-22 (1-5), 2 text figures. *Sendai*.

An interesting Eocene foraminiferal fauna is described from these Japanese Islands. A new species of *Nummulites* is described, and the paper is illustrated by unusually beautiful plates from photographs.

Silvestri, A.

Sulla "Bradya tergestina" Stache.

Riv. Ital. Pal., Ann. 30, 1924, pp. 17-26, 1 plate. *Parma*.

Copious notes are given on this peculiar form, and a double plate of excellent sections.

Silvestri, A.

Sulle Ellissonodosarine della Molassa di Varano in Lombardia.

Atti Soc. Ital. Sci. Nat., vol. 64, 1925, pp. 49-60, text figs.

1-8. *Parvia*.

Notes are given on the foraminifera of this locality, and figures given of several of the Nodosarine forms.

Cushman, J. A.

An Introduction to the Morphology and Classification of the Foraminifera.

Smithsonian Misc. Coll., vol. 77, No. 4, July 21, 1925, pp. 1-77, pls. 1-16, 11 text figures. *Washington*.

This paper is intended as an introduction to the study of this group, and to give to the beginner some of the necessary tools to use in the way of general hints, the general scheme of classification as found in recent works, and a fairly extensive bibliography. It is not intended to be exhaustive or to set forth new ideas.

Nuttall, W. L. F.

Indian Reticulate Nummulites.

Ann. Mag. Nat. Hist., ser. 9, vol. 15, June 1925, pp. 661-667, pls. 37, 38. *London*.

Several species of *Nummulites* from the Oligocene of India are figured and described. Two of the four species are new.

Thomas, E. T.

An Aid to the Study of Foraminifera.

Bull. Amer. Assoc. Petr. Geol., vol. 9, No. 3, May-June, 1925,
pp. 667-669, 1 text figure. Chicago.

This paper describes a new form of slide, a combination of celluloid punched with numerous holes cemented to a glass slide by the use of acetone. These are used for filing species from a single station.

Rutten, L.

Some notes on Foraminifera from the Dutch Indies.

Proceedings, Kon. Akad. Wetenschappen Amsterdam, vol. 27, 1924, pp. 1-6, text figures 1-9. Amsterdam.

Figures of *Linderina* and *Lepidocyclus* are given with special reference to the embryonic chambers. The occurrence of various forms in the Dutch Indies is discussed.

Rutten, L.

Over de Foraminiferenfauna en den Ouderdom van Kalksteen uit Zuid-Celebes, Afkomstig uit de Groep der Vischresten-berattende Gesteenten.

Verh. Jaarboek van het Mijnwezen in Ned. Oost-Indie, 1923 (1924), pp. 180-183, plate. The Hague.

Figures of *Spirocyclus*, *Heterostegina* and *Lepidocyclus* are given, and a new species, *Lepidocyclus brouweri*, is described.

Ozawa, Y.

Palaeontological and Stratigraphical Studies in the Permo-Carboniferous Limestone of Nagato. Part II. Paleontology.

Journ. Coll. Sci. Imp. Univ. Tokyo, vol. 45, Art. 6, June, 1925, pp. 1-90, pls. 1-14. Tokio.

This is an important and well illustrated paper on the later Palaeozoic of Japan, in which 67 species and varieties are discussed with much detail and excellently figured. The family Fusulinidae is recognized, and a new classification given. A total of 21 new species and varieties are described.

Hofker, J.

On Heterogamy in Foraminifera.

Tijdschr. d. Ned. Dierk. Vereen, ser. 2, vol. 19, 1925, pp. 68-70. The Hague.

Notes are given on the cultivation of living foraminifera, and the life cycle. Several megalospheric generations followed in succession before a microspheric one developed.

CONTRIBUTIONS FROM THE CUSHMAN LABORATORY FOR FORAMINIFERAL RESEARCH

VOLUME 1, PART 4, JANUARY 1926

17. THE GENUS CHILOSTOMELLA AND RELATED GENERA

By JOSEPH A. CUSHMAN

In 1850 Reuss erected the genus *Chilostomella* to include two species, *C. ovoidea* Reuss and *C. czizeki* Reuss, both from the Miocene of Central Europe. The type species, *C. ovoidea* Reuss, was taken up by Brady, and in the *Challenger* Report all the other described species were made synonyms of *C. ovoidea* Reuss. A study of the figures and descriptions together with available recent and fossil specimens has seemed to show that the problem is not such a simple one. Instead of there being but one species involving both fossil and recent forms there are probably two genera with several distinct species. The Cretaceous and some of the Eocene forms are distinguishable from the Recent and most of the Tertiary ones in the apertural characters, and on this basis a new genus has been erected for them. The relationships will be indicated.

Genus **CHILOSTOMELLA** Reuss, 1850

Chilostomella REUSS (type *C. ovoidea* REUSS), Denkschr. Akad. Wiss. Wien, vol. 1, 1850, p. 379.—H. B. Brady, Rep. Voy. *Challenger*, Zoology, vol. 9, 1884, p. 436.—Chapman, The Foraminifera, 1902, p. 182.—Cushman, Bull. 71, U. S. Nat. Mus., pt. 4, 1914, p. 2; Bull. 104, pt. 5, 1924, p. 1.

Test free, composed of a series of chambers in a coil, each chamber making a half coil of 180° and embracing so that but a small part of the base of the preceding chamber is visible from the exterior; wall smooth, finely perforate, either thin and transparent or thick and opaque; aperture at the inner margin of the ventral face of the chamber, in a semicircle, narrow, often with a slightly upturned lip.

In this genus the aperture is a very narrow, curved slit, at the base of the chamber at the inner margin. In young specimens there is a slight tendency to have a broader aperture correspond-

ing roughly with that in the following genus which is its main characteristic.

CHILOSTOMELLA OVOIDEA Reuss

Plate 11, figs. 1 *a-e*

Chilostomella ovoidea REUSS, Denkschr. Akad. Wiss. Wien, vol. 1, 1850, p. 380, pl. 48, figs. 12 *a-e*.

Test ovoid, circular in transverse section, somewhat tapering at the basal end in front view, two-thirds as broad as long, greatest width nearly twice that at the aperture; wall smooth; aperture a narrow slit with a very slight lip.

Reuss' specimens were from the Miocene of Austria. As stated above some authors have referred all specimens of the genus to this species of Reuss. The many recent specimens I have had for study have failed to show anything at all close to this species of Reuss. There are three and perhaps four or more recent forms which have apparently very definite distributions. Of the fossil forms there are several probably distinct species. For this reason it is impossible to correctly place all the references to *C. ovoidea* in their proper place without a study of the specimens involved in each case. In some cases where figures are given this may be done.

CHILOSTOMELLA CZIZEKI Reuss

Plate 11, figs. 2 *a-d*

Chilostomella czizeki REUSS, Denkschr. Akad. Wiss. Wien, vol. 1, 1850, p. 380, pl. 48, figs. 13 *a-d*.

This species is figured by Reuss from the same locality as that from which *C. ovoidea* Reuss was described. It is a much more elongate form, and may be a varietal form of *C. ovoidea*. Schwager, (Boll. Com. Geol. Ital., vol. 8, 1877, p. 26, pl., fig. 70), refers specimens from the Tertiary of Italy to *C. czizeki* Reuss.

CHILOSTOMELLA OOLINA Schwager

Plate 11, figs. 3-10

Chilostomella oolina SCHWAGER, Boll. Com. Geol. Ital., vol. 9, 1878, p. 527, pl. 1, fig. 16.

Chilostomella ovoidea H. B. BRADY (in part) (not Reuss), Rep. Voy. Challenger, Zoology, vol. 9, 1884, p. 436.—Egger, Abhandl. kön. bay. Akad. Wiss. München, Cl. II, vol. 18, 1893, p. 305, pl. 9, figs. 1, 2.—Goës, Kongl. Svensk. Vet. Akad. Handl., vol. 25, No. 9, 1894, p. 53, pl. 9, figs. 512-516.—Rhumbler, Nordisches Plankton, pt. 14, Foraminiferen, 1901, p. 11, figs. 1-3, in text.—Cushman, Bull. 104, U. S. Nat. Mus., pt. 5, 1924, p. 2, pl. 1, figs. 8-10.

Test elongate, three times as long as wide, both ends broadly rounded, sides nearly parallel for most of their length, wall thin, distinctly punctate, aperture very narrow, curved.

Length usually less than 1 mm.

The recent specimens from much of the Atlantic region and from some of the Pacific may be referred to this species of Schwager described from the Pliocene of Sicily. It is a much more elongate species than the other recent ones, and has little in common with *C. ovoidea* Reuss, to which it has usually been referred. Probably there are other recent references which should be placed here but owing to lack of figures this is impossible at the present time. It is a pelagic species at least in some stages of its development.

CHILOSTOMELLA GRANDIS Cushman

Plate 11, figs. 12 *a-c*

Chilostomella grandis CUSHMAN, Proc. U. S. Nat. Mus., vol. 51, 1917, p. 662; Bull. 100, U. S. Nat. Mus., pt. 4, 1921, p. 283, pl. 57, figs. 5 *a-c*.

Test broadly elliptical in side view, in end view circular; two chambers visible from the exterior; wall thick and opaque, smooth; aperture in end view semicircular with a flangelike truncated lip.

Length up to 4 mm. or more.

This species known from several stations in the Philippine region is the largest and finest of the genus. It has a very heavy test and is evidently a bottom-living species.

In the Australian region there is a large thick-walled *Chilostomella* which in many of its characters resembles *C. grandis* Cushman. It has much more pointed ends, however, and there is not evident the straight sided effect that is so apparent in adult *C. grandis*. The aperture, however, is somewhat similar and especially the thick polished, opaque wall in the adult. I have excellent specimens from off New Zealand, off the Big King in 98 fathoms, and off the Poor Knights, 60 fathoms. This is the form I have recorded as *C. ovoidea*, (Proc. U. S. Nat. Mus., vol. 56, 1919, p. 621). There seem to be both microspheric and megalospheric forms present.

CHILOSTOMELLA MILLETTI Cushman, n. sp.Plate 11, figs. 13 *a, b*

Chilostomella ovoidea MILLETT (in part) (not Reuss), Journ. Roy. Micr. Soc., 1901, p. 2, pl. 1, figs. 2 *a, b* (not figs. 3 *a-c*).

Test ovate in outline, broadest below the middle, two-thirds as broad as long, only the very base of the penultimate chamber visible, the last-formed chamber nearly completely covering it; wall dense and opaque with a granular surface; aperture nearly at the tip of the test.

Length 0.5 mm.

Millett had this species from the Malay region. Heron-Allen and Earland refer to it some of their Antarctic Expedition material. So far as known this is the only species with any ornamentation, the test in all other species being smooth.

CHILOSTOMELLA CYLINDROIDES ReussPlate 11, figs. 14 *a-c*, 15 *a-d*

Chilostomella cylindroides REUSS, Zeitschr. deutsch. geol. Ges., vol. 3, 1851, p. 80, pl. 6, fig. 43.—Bornemann, l. c., vol. 7, 1855, p. 343, pl. 17, fig. 1.—Hantken, Mitth. Jahrb. ungar. geol. Anstalt., vol. 4, 1875 (1881), p. 63, pl. 7, fig. 7.

Test about twice as long as broad, the sides only slightly convex, ends truncately rounded; wall smooth; aperture narrow, curved.

Reuss described and figured this species from the Oligocene of Hermsdorf near Berlin. Bornemann figures a somewhat stouter form from the same locality under this name. Hantken's specimens from the Upper Eocene of Hungary are about identical with Reuss' original figures. No forms of just this description are known from the later Tertiary.

CHILOSTOMELLA TENUIS BornemannPlate 11, figs. 16 *a-c*

Chilostomella tenuis BORNEMANN, Zeitschr. deutsch. geol. Ges., vol. 7, 1855, p. 343, pl. 17, figs. 2 *a-c*.—Reuss, Denkschr. Akad. Wiss. Wien, vol. 25, 1865, p. 156.—Hantken, Mitth. Jahrb. ungar. geol. Anstalt., vol. 4, 1875 (1881), p. 64.

Test small, cylindrical, sides nearly parallel, ends broadly rounded, 3 or 4 times as long as broad, punctate, smooth; aperture narrow.

Bornemann described and figured this slender species from the Oligocene of Hermsdorf near Berlin. Reuss also records it from the Middle Oligocene of Germany and Hantken from the Upper Eocene of Hungary. This is nearest like the Recent and Pliocene *C. oolina* in its narrow form.

Genus **CHILOSTOMELLOIDES** Cushman, new genus

Test in general characters similar to *Chilostomella* but the apertural characters distinct. In *Chilostomelloides* the aperture instead of being a long narrow slit is often circular and stands away from the preceding chamber, being entirely closed in by its own chamber wall in some species. In others it is nearly closed except for a narrow segment that is made by the previously formed chamber. Type species *Chilostomelloides oviformis* (Sherborn and Chapman).

The three recorded species which evidently belong to this genus are from the Upper Cretaceous and Eocene of Europe and America.

CHILOSTOMELLOIDES OVIFORMIS (Sherborn and Chapman)

Plate 11, figs. 17 *a-d*, 21 *a-c*

Lagena (Obliquina) oviformis SHERBORN and CHAPMAN, Journ. Roy. Micr. Soc., 1886, p. 745, pl. 14, figs. 19 *a-d*.

Chilostomella oviformis SHERBORN and CHAPMAN, Journ. Roy. Micr. Soc., 1889, p. 485, pl. 11, fig. 13.

Test oval in front view, ends broadly rounded; wall smooth; aperture circular or nearly so, standing out at a distinct angle from the general contour of the test, with a thickened lip.

Length up to 1 mm.

The type specimens are from the Eocene (London Clay) of England. There are specimens apparently identical with these from the Alazan Clay of Mexico. The apertural characters and general contour are the same. They are from Rio Buena Vista, State of Vera Cruz, Mexico, collected by T. Wayland Vaughan. With these is a smaller form which probably belongs to true *Chilostomella*, but preservation is not sufficiently good for description.

CHILOSTOMELLOIDES EXIMIA (Franzenau)

Plate 11, figs. 18 *a-c*

Chilostomella eximia FRANZENAU, Termesz. Füzetek, vol. 11, 1889, pp. 147, 206, woodcut; Math. termesz. értesítő, vol. 7, 1889, p. 248, pl. 4, fig. 3; Math. Nat. Ber. Ungarn, vol. 7, 1889, p. 67, pl. 3, fig. 3 *a-c*.

This species from the Eocene of Central Europe is very close to *C. oviformis*, the apertural end somewhat more tapering and apparently the aperture close to the end of the chamber.

CHILOSTOMELLOIDES EOCENICA Cushman, n. sp.Plate 11, figs. 20 *a-c*

Test elongate, about $2\frac{1}{2}$ times as long as broad, ends rounded, sides gently convex, tapering toward either end; wall smooth, very finely punctate; aperture semicircular, standing out at an angle from the contour of the test, with a distinct, slightly thickened lip.

Length 0.5 mm.

Holotype (Cushman Coll. No. 4365) from the Midway, Lower Eocene of the Mexia Oil Field, Texas.

In this species the test is more tapering toward the ends and more elongate than in *C. oviformis*, the wall is thinner, and the aperture not wholly free from the preceding chamber.

CHILOSTOMELLOIDES CYCLOSTOMA (Rzehak)Plate 11, figs. 19 *a-c*

Chilostomella cyclostoma RZEHAK, Ann. k. k. Nat. Hofmuseum, vol. 3, 1888, p. 258, pl. 11, figs. 1 *a-c*.

This species from the Upper Cretaceous of Central Europe is closest to *C. eocenica* Cushman, but is broader and the ends much more broadly rounded.

Figures are given of the various species adopted from the original figures of the types.

Genus CHILOSTOMELLINA Cushman, new genus

Test composed of a few inflated chambers, the last-formed one almost completely enveloping the preceding ones, and the chambers rapidly increasing in size as added; wall thin, finely perforate; aperture small, crescentiform with the sides of the chamber with a series of reëntnants at each side.

Type species *Chilostomellina fimbriata* Cushman, new species.

This is a peculiar genus, in some characters related to *Chilostomella* especially in the apparent alternation of chambers and the embracing character of each newly added chamber.

CHILOSTOMELLINA FIMBRIATA Cushman, n. sp.Plate 11, figs. 22 *a-c*

Characters as given for the genus above, the whole test subglobular, slightly larger than broad; the wall very thin, translucent, the sides of the chamber next to the aperture markedly fimbriate.

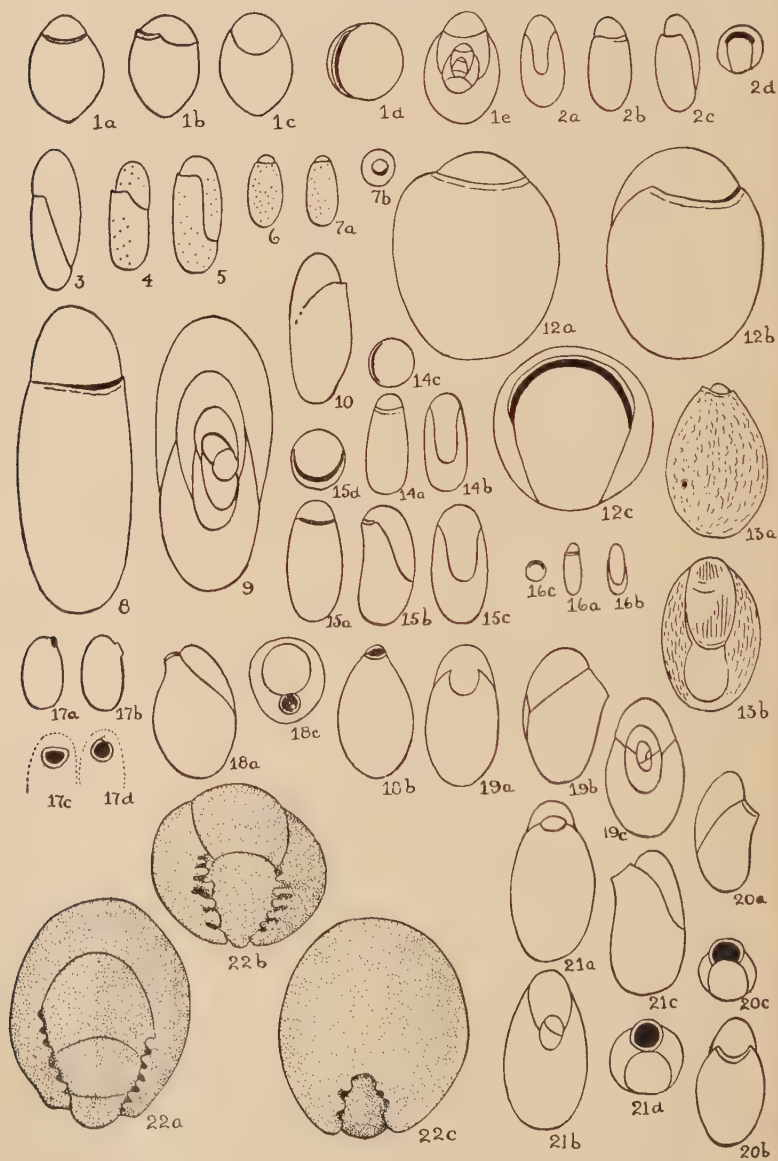
Length 0.45 mm.; breadth 0.35 mm.

Type specimen (U. S. N. M. Coll. No. 20280), from *Albatross* station D3608, in 276 fathoms, Bering Sea.

This is not an abnormal specimen as several others in various stages of development show the same characters.

EXPLANATION OF PLATE 11

- IGS. 1 *a-e*. *Chilostomella ovoidea* Reuss (After Reuss).
 IGS. 2 *a-d*. *Chilostomella czizeki* Reuss (After Reuss).
 IG. 3. *Chilostomella oolina* Schwager (After Schwager).
 IGS. 4, 5. *Chilostomella oolina* Schwager (*C. ovoidea* Egger) (After Egger).
 IGS. 6, 7. *Chilostomella oolina* Schwager (*C. ovoidea* Goës) (After Goës).
 IGS. 8, 9. *Chilostomella oolina* Schwager (*C. ovoidea* Rhumbler) (After Rhumbler).
 IG. 10. *Chilostomella oolina* Schwager (*C. ovoidea* Cushman) (After Cushman).
 IGS. 12 *a-c*. *Chilostomella grandis* Cushman (After Cushman).
 IGS. 13 *a, b*. *Chilostomella milletti* Cushman, n. sp. (*C. ovoidea* Millett) (After Millett).
 IGS. 14 *a-c*. *Chilostomella cylindroides* Reuss (After Reuss).
 IGS. 15 *a-d*. *Chilostomella cylindroides* Reuss (After Hantken).
 IGS. 16 *a-c*. *Chilostomella tenuis* Bornemann (After Bornemann).
 IGS. 17 *a-d*. *Chilostomelloides oviformis* (Sherborn and Chapman) (*Lagena oviformis* Sherborn and Chapman) (After Sherborn and Chapman).
 IGS. 18 *a-c*. *Chilostomelloides eximia* (Franzenau) (After Franzenau).
 IGS. 19 *a-c*. *Chilostomelloides cyclostoma* (Rzehak) (After Rzehak).
 IGS. 20 *a-c*. *Chilostomelloides eocenica* Cushman, n. sp.
 IGS. 21 *a-c*. *Chilostomelloides oviformis* (Sherborn and Chapman).
 IGS. 22 *a-c*. *Chilostomellina fimbriata* Cushman, n. sp.



18. SOME FOSSIL BOLIVINAS FROM MEXICO

By JOSEPH A. CUSHMAN

In some parts of the Alazan clays of Mexico, especially those of very fine texture there are abundant foraminifera. These wash out with all their details well preserved for study. Among them are several species of *Bolivina* which seem to be different from any described species. These species and varieties have a very definite vertical distribution.

BOLIVINA MEXICANA Cushman, n. sp.

Plate 12, fig. 2

Test much compressed, the early portion with a slight keel, later chambers developing a wider keel; chambers of the early portion low, several times as broad as high, gradually increasing in height as added until in the adult the chambers are only slightly greater in width than in height, inflated slightly in later development; sutures distinct, in the early portion appearing at the surface as a double line between the chambers, in later development less marked and slightly obscured by a slight imbrication of the chambers; wall smooth, finely punctate; aperture elongate with a slight lip.

Length up to 1.2 mm.

Type specimen (Cushman Coll. No. 4366) from clays on Panuco Railroad between kilometer posts 21 and 22, state of Vera Cruz, Mexico.

In some of its characters this species resembles forms referred by various authors to *Bolivina beyrichi* Reuss. A study of European material of *Bolivina beyrichi* Reuss shows that as in the type figure while there are backward projections from the basal angles of each chamber at the periphery the test itself is not truly keeled. A reference to the figures given as *B. beyrichi* from various geologic formations as well as from recent seas will show that many of these have little in common with the typical form described by Reuss.

Bolivina mexicana has a rather wide distribution in the Alazan clays of Mexico, and is often very abundant. There are two varieties which are easily distinguished and which have very definite horizons where they occur in great numbers.

BOLIVINA MEXICANA Cushman, n. sp., var. **ALIFORMIS** Cushman, n. var.
Plate 12, figs. 3, 4 *a*, *b*

Test differing from the typical form in the development of a broad transparent keel which extends about the entire test; the sutures are limbate and expanded toward the central portion of the test, the chambers very slightly imbricate in later development.

Type specimen (U. S. N. M. Coll. No. 353838), from Alazan shale, left bank of Tuxpan River, at bluff S. 25° E. about 0.5 km. from Tumbadero Hacienda House, Vera Cruz, Mexico, collected by T. Wayland Vaughan.

At the type horizon the variety is very abundant. In some respects this variety resembles a form referred by Brady to *Bolivina beyrichi*, var. *alata* (Rep. Voy. Challenger, Zoology, vol. 9, 1884, pl. 53, fig. 4.) The Mexican form, however, has very different sutures, in that respect more resembling *Bolivina schwageriana* H. B. Brady.

Both microspheric and megalospheric forms are shown on the plate, the latter form with large proloculum starting off with high chambers, and not developing the more flaring shape of the microspheric form.

BOLIVINA MEXICANA Cushman, n. sp., var. **HORIZONTALIS** Cushman, n. var.
Plate 12, figs. 5 *a*, *b*

Variety differing from the typical in the characters of the periphery, each chamber having a definite thin keel with the angle not at the base, and projecting backward but nearer mid-way of the chamber and pointing in a nearly horizontal direction, the sutures also less oblique than in the typical, and more deeply incised.

Type specimen (U. S. N. M. Coll. No. 353839), from soft grayish clay, southwest slope of Cuesta Blanca, near Zacamixtle, Vera Cruz, Mexico, collected by T. Wayland Vaughan.

This variety is distinct in its peculiar horizontal trend of the sutures and especially the keeled portion. It is common at the above station, and I have also seen it from other localities in Mexico. It is evidently a varietal form of *Bolivina mexicana*.

BOLIVINA ALAZANENSIS Cushman, n. sp.
Plate 12, figs. 1 *a*, *b*

Test in transverse section rhomboid, much thicker in the middle thence thinning toward the periphery which has a narrow keel only slightly angled at the chambers; chambers distinct,

urved, and oblique, in later development tending to develop a
be at the base near the central portion, and slightly imbricate;
utures very distinct, appearing at the surface as a double line
n the early portion, fused in the middle of the test to form a
rominent ridge, slightly broken up near the apertural end; wall
mooth, very distinctly punctate; aperture elongate.

Length up to 0.70 mm.

Type specimen (U. S. N. M. Coll. No. 353840), from light
ray, soft clay on Tampico-Panuco Railroad, kilometer post
0.15, state of Vera Cruz, Mexico, collected by T. Wayland
Vaughan.

I have this species in my own collection from many stations in
his same general region. It is widely distributed in the Alazan
lays of Mexico. A related form to this is one I have figured
rom the Red Bluff clay of St. Stephens, Alabama (U. S. Geol.
urvey, Prof. Paper 133, 1923, p. 19, pl. 3, fig. 2). The sutures,
however, are quite different.

BOLIVINA TECTIFORMIS Cushman, n. sp.

Plate 12, figs. 6 *a*, *b*

Test small, compressed, thickest along the median line thence
hinning toward the periphery which is rounded; chambers
istinct, oblique, not curved or only very slightly so; sutures
istinct, very much thickened, fusing in the median line to form
thick rounded ridge, the wall over the middle of the chamber
hin and nearly transparent, the sutures and median line thick
nd opaque; wall coarsely punctate, the earlier portion with an
rnamentation consisting of slightly oblique longitudinal chan-
els and ridges, most distinct on the thickened sutures becoming
bsolute in late chambers; aperture terminal, elliptical, with
thickened lip.

Length up to 0.45 mm.

Type specimen (U. S. N. M. Coll. No. 353841), from Alazan
lays, bluff on Rio Buena Vista, 2 kms. in a straight line above
s confluence with Rio Tuxpan, state of Vera Cruz, Mexico,
collected by T. Wayland Vaughan.

This is a peculiar little species which is very distinctive in
ome parts of the Alazan where it often occurs in great numbers.

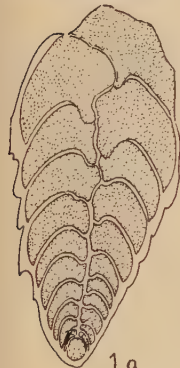
It is distinct in its thickenings of the sutures and median line,
he coarse punctations and unusual fine ornamentation of the
arly chambers. The blocklike form with the broadly rounded
nitial end, the truncate apertural end, and the nearly parallel
ides are distinctive.

EXPLANATION OF PLATE 12

- FIGS. 1 *a, b.* *Bolivina alazanensis* Cushman, n. sp. X 75.
 a, front view; *b*, apertural view.
- FIG. 2. *Bolivina mexicana* Cushman, n. sp. X 75.
- FIGS. 3, 4 *a, b.* *Bolivina mexicana* Cushman, n. sp., var. *aliformis* Cushman, n. var.
 3, front view of megalospheric specimen; 4 *a*, front view of microspheric specimen; 4 *b*, apertural view.
- FIGS. 5 *a, b.* *Bolivina mexicana* Cushman, n. sp., var. *horizontalis* Cushman, n. var.
 a, front view; *b*, apertural view.
- FIGS. 6 *a, b.* *Bolivina tectiformis* Cushman, n. sp. X 75.
 a, front view; *b*, apertural view.



1b



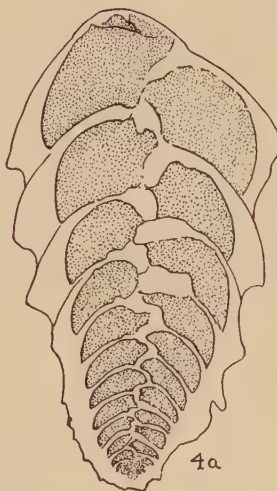
1a



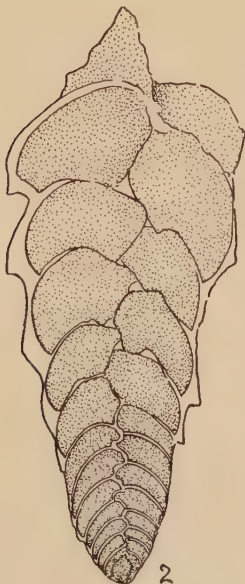
3



4b



4a



2



5b



5a



6b



6a

19. TRIFARINA IN THE AMERICAN EOCENE AND ELSEWHERE

By JOSEPH A. CUSHMAN

A study of Jackson Upper Eocene material from Jackson, Mississippi, has revealed a species of *Trifarina* present there. It is a minute form and might be easily overlooked. A comparison with other Upper Eocene material from the Coastal Plain and recent material from the Atlantic and Pacific shows that it may be distinguished from either, yet is clearly related to both recent forms. The form occurs at other localities in the Upper Eocene of the Coastal Plain of the United States.

Genus **TRIFARINA** Cushman, 1923

Rhabdogonium H. B. BRADY (not Reuss), Rep. Voy. *Challenger*, Zoology, vol. 9, 1884, p. 524 (and subsequent authors).

Triplasia CUSHMAN (not Reuss), Bull. 71, U. S. Nat. Mus., pt. 3, 1913, p. 62.

Trifarina CUSHMAN, Bull. 104, U. S. Nat. Mus., pt. 4, 1923, p. 99.

Test elongate, triangular in transverse section; the early chambers in an irregular spiral, later ones very loosely so or uniserial; wall thin, translucent, finely punctate; aperture terminal, not radiate, at the end of a short, often phialine lip.

In the strict sense in which this genus is used the most definite forms have been known from the present oceans. There is a larger stouter species known from the Pacific, *T. reussi* Cushman, and a much smaller, more slender one from the Atlantic, *T. bradyi* Cushman. In the Pacific this last species is represented by a distinguishable variety noted below, and in the American Upper Eocene is another variety as later recorded in this paper.

TRIFARINA BRADYI Cushman

Rhabdogonium tricarinatum H. B. BRADY (not *Vaginulina tricarinata* D'ORBIGNY), Rep. Voy. *Challenger*, Zoology, vol. 9, 1884, p. 525, (in part).—H. B. Brady, Parker and Jones, Trans. Zool. Soc. London, vol. 12, 1888, p. 223, pl. 45, fig. 3.—Cushman, Bull. 104, U. S. Nat. Mus., pt. 4, 1923, p. 99, pl. 22, figs. 5-7, 9 (3, 4, 8?).

The Atlantic form has a slightly larger test than the Pacific one, has the sides more concave especially in later growth, and the carinae at the angles higher and more prominent, the wall thinner, less distinctly punctate. Plate 67, fig. 3, of the

Challenger Report is from a specimen dredged at *Challenger* Station 192, off the Ki Islands according to notes furnished me by Capt. F. A. Potts. The source of figs. 1 and 2 is not determined.

I have examined numerous specimens from various parts of the Pacific, and in general they seem to keep to the slightly smaller size, less prominent carinae, and more distinctly punctate test.

Specimens from the Filter Quarries of Batesford, Victoria, Australia, seem to be somewhat larger than the general run of recent Pacific specimens, and are certainly more like the recent Pacific form than that of the Atlantic. Heron-Allen and Earland refer it to *Rhabdogonium tricarinatum*. A further study of d'Orbigny's original model of *Vaginulina tricarinata* shows it to be uniserial throughout, the aperture at one angle and removes it from any relation to the genus under consideration.

TRIFARINA REUSSI (Cushman)

Rhabdogonium minutum H. B. BRADY (not *R. minutum* REUSS), Rep. Voy. *Challenger*, Zoology, vol. 9, 1884, p. 526, pl. 67, figs. 4-6.—Bagg, Proc. U. S. Nat. Mus., vol. 34, 1908, p. 145.—Chapman, Journ. Linn. Soc. London, Zool., vol. 30, 1910, p. 412 [?].

Triplasia reussi CUSHMAN, Bull. 71, U. S. Nat. Mus., pt. 3, 1913, p. 63, pl. 39, fig. 3.

Trifarina reussi CUSHMAN, Bull. 104, U. S. Nat. Mus., pt. 4, 1923, p. 99.

Test thick and short, triangular in transverse section; chambers few, somewhat carinate; walls roughish, thick; apertural and with a short, fairly large neck, often with a fringelike border about the aperture itself.

Length 0.80 mm.

This species is known only from the tropical Pacific, and as has been stated in the above references, is distinct from Reuss' fossil species from Galicia.

TRIFARINA BRADYI Cushman, var. ADVENA Cushman, n. var.

Variety differing from the typical in the smaller size, more distinctly punctate, thicker wall; sides hardly concave.

Length 0.30 mm.

The type specimen (U. S. N. M. Coll. No. 353843), from the Upper Jackson at Jackson, Mississippi. It is found at other stations in the Upper Eocene of the Coastal Plain.

From what may be seen from a study of these three forms, the Upper Eocene one is more like the recent Pacific than like the recent Atlantic form. It is smaller, thicker, and more punctate than either.

There are a few other fossil forms that may possibly belong in this genus, but they are not sufficiently well characterized to place them without reference to original material.

20. A PECULIAR FRONDICULARIA FROM MEXICO AND TRINIDAD

By JOSEPH A. CUSHMAN

In the Alazan clays of the Coastal Plain of Mexico there is a peculiar, elongate species of *Frondicularia*. It occurs at several stations, and is very constant in its characters. The same species has been found to occur at Brasso, Trinidad, B. W. I.

The relationships of this species are very interesting. A description follows:

FRONDICULARIA MEXICANA Cushman, n. sp.

Plate 13, figs. 5 *a-c*

Test somewhat compressed, very elongate, narrow, the peripheral portion with three sharp, platelike carinae, one in the middle line, the other two lateral; the sides except for the initial end parallel, initial end rounded, slightly tapering, the early portion of the test convex, ornamented by a few longitudinal raised costae, the later portion concave, smooth; chambers rather indistinct; sutures hardly if at all depressed; aperture terminal, central, radiate.

Length up to nearly 1 mm.

Type specimen (U. S. N. M. Coll. No. 353842), from dark gray Alazan clay, Rio La Puerta, Soledad Crossing, Vera Cruz, Mexico, collected by T. Wayland Vaughan. There are also specimens in the U. S. National Museum collections from the Alazan of Mexico collected by Doctor Vaughan from Arroyo Camalla, Tepitzintla-El Humo Road, 4 kms. E. of El Humo; from Rio Buena Vista, 2 kms. in a straight line above its confluence with Rio Tuxpan, Vera Cruz; and from the type locality of the Alazan shale at Rio Buena Vista, just south of crossing of the Alazan to Moyutla road, Vera Cruz.

At its type locality *Fron dicularia mexicana* occurs with a species of *Orthophragmina*.

The specimens from Brasso, Trinidad, are very similar.

In its relationships this species is Indo-Pacific. One of the most closely related species is *Fron dicularia australis* Heron-Allen and Earland, described from the Miocene, "Filter Quarry," Victoria, Australia (Journ. Roy. Micr. Soc., 1924, p. 157, pl. 10, figs. 56-58). It also resembles more remotely *F. bicostata* Barrer from the Tertiary of Luzon, Philippines (in von Drasche, frag. Geol. Insel Luzon, 1878, p. 91, pl. 5, fig. 13). Its relationship to the recent form figured by Sidebottom from 465 fathoms off the East Coast of Australia and referred to *F. tenera* (Bornemann) should also be noted.

Many of the species of the Alazan clays of Mexico show this East Indian relationship as has been noted in an earlier paper on *tritaxilina*.

There is a species in the Pliocene of the American West Coast which also forms a link in this series and probably shows that a similar species occurred on the West Coast of America after *fron dicularia mexicana* became extinct on the eastern side.

21. MIOCENE SPECIES OF NONIONINA FROM CALIFORNIA

By JOSEPH A. CUSHMAN

There are in the Monterey Shale in certain portions enormous numbers of several species of *Nonionina*. Three of these are closely allied species, but they have distinctive characters and very definite stratigraphic ranges. The fourth species is here referred to the Recent *Nonionina auris* (d'Orbigny), and has a somewhat wider range. The figures are intended to bring out these specific characters so that the species may be distinguished from one another.

NONIONINA MEDIO-COSTATA Cushman, n. sp.

Plate 13, figs. 1 a-c

Test slightly longer than broad, periphery rounded, composed of numerous chambers, 15 or more in the last-formed coil, slight-

ly umbilicate; sutures distinct, slightly depressed, gently curved, forming nearly a right angle with the periphery, the area between the sutures raised and the inner end with a definite costa rounded toward the umbilicus; in apertural view the apertural face gently convex, definitely higher than broad, the aperture an arched opening at the base of the apertural face between it and the preceding coil.

Length up to 0.65 mm.; breadth 0.40 mm.; thickness 0.22 mm.

Type specimen (Cushman Coll. No. 4367) from Miocene, Monterey shale, Sect. 24, T.28,R.14, San Luis Obispo Co., California.

The distinguishing characters are especially the narrow apertural face and test with the raised costae between the sutures.

NONIONINA COSTIFERA Cushman, n. sp.

Plate 13, figs. 2 a-c

Test longer than broad, periphery acute, almost keeled, composed of numerous chambers, as many as 20 in the last-formed coil, umbilicate; sutures distinct, limbate, slightly raised above the general surface, increasing in thickness and height toward the umbilicus, forming an acute angle with the periphery; in apertural view, the apertural face heart-shaped or broadly triangular, flattened or slightly concave, the aperture a very small semi-circular opening at the base of the apertural face, between it and the preceding coil.

Length up to 1 mm.; breadth 0.60 mm.; thickness 0.35-0.40 mm.

Type specimen (Cushman Coll. No. 4368) from Miocene, Monterey shale, Sect. 24, T.28,R.14, San Luis Obispo Co., California.

The distinguishing characters are especially the limbate and costate sutures and the very broad triangular apertural face.

NONIONINA INCISA Cushman, n. sp.

Plate 13, figs. 3 a-c

Test longer than broad, periphery acute, composed of numerous chambers, about 15 in the last-formed coil, slightly umbilicate; sutures distinct, deeply incised, curved, forming an acute angle with the periphery; wall smooth; in apertural view the apertural face broad, slightly convex, the aperture an elongate narrow arched opening at the base of the apertural face between it and the preceding coil.

Length up to 0.60 mm.; breadth 0.40 mm.; thickness 0.25-0.30 mm.

Type specimen (Cushman Coll. No. 4369), from Miocene, Monterey shale, Sect. 24, T.28,R.14, San Luis Obispo Co., California.

This species may be distinguished from the two preceding by the lack of definite costae and the broad apertural face. The sutures are sometimes very deeply incised, and the chambers between correspondingly convex.

NONIONINA AURIS (d'Orbigny)

Plate 13, figs. 4 *a-c*

Valvulina auris D'ORBIGNY, Voy. Amér. Mérid., 1839, "Foraminifères," p. 47, pl. 2, figs. 15-17.

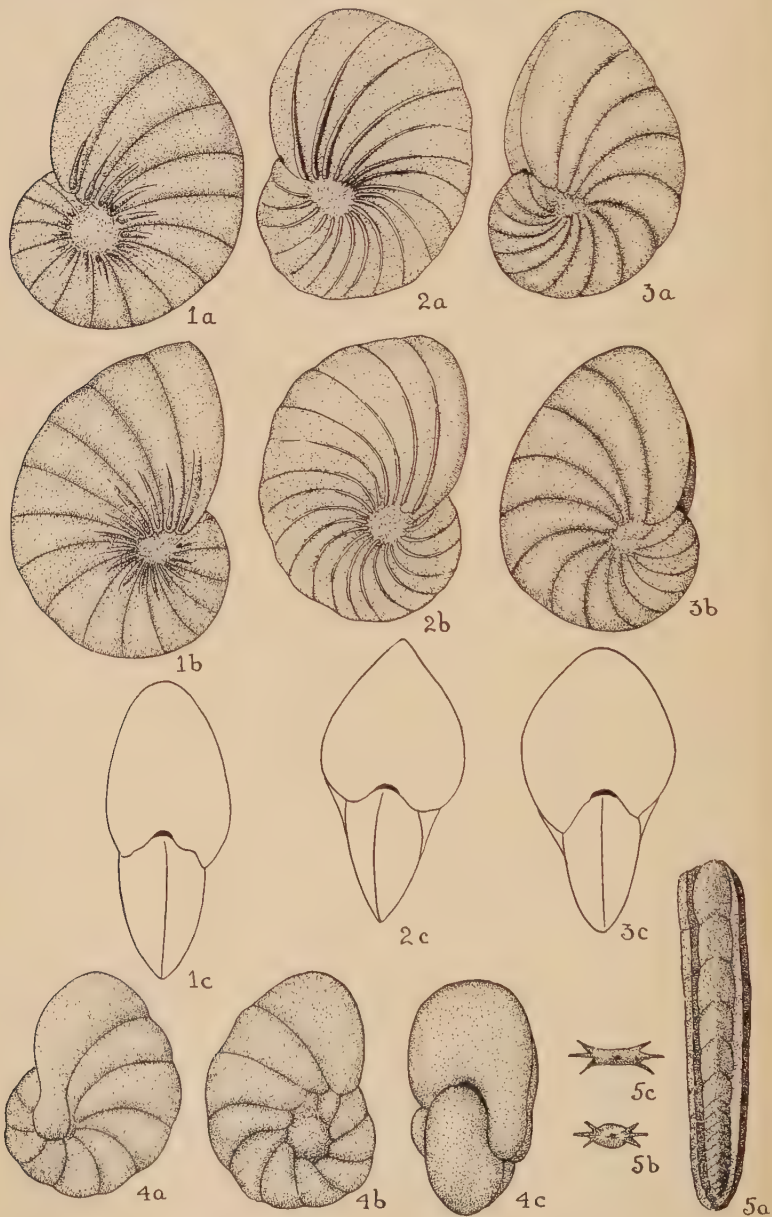
There is figured a specimen of *Nonionina* which is very close to *N. auris* (d'Orbigny) described by d'Orbigny from the West Coast of South America. I have figured a form (Contrib. Cushman Lab. Foram. Res., vol. 1, pt. 2, 1925, p. 44, pl. 7, figs. 3 *a-c*) from Queen Charlotte Sound, which is similar to that figured by d'Orbigny but having a broader stouter form with fewer chambers. The Miocene specimen figured above which is typical of those found in the Monterey has more chambers and is closer in this respect to d'Orbigny's type figure, but is somewhat stouter.

The figured specimen (Cushman Coll. No. 4370) is from Miocene, Monterey shale, Sect. 24, T.28,R.14, San Luis Obispo Co., California.

This species never seems to be abundant in the material examined, but is very constant in its characters.

EXPLANATION OF PLATE 13

- FIGS. 1 *a-c*. *Nonionina medio-costata* Cushman, n. sp. X 75.
a, b, opposite sides; *c*, apertural view.
- FIGS. 2 *a-c*. *Nonionina costifera* Cushman, n. sp. X 45.
a, b, opposite sides; *c*, apertural view.
- FIGS. 3 *a-c*. *Nonionina incisa* Cushman, n. sp. X 75.
a, b, opposite sides; *c*, apertural view.
- FIGS. 4 *a-c*. *Nonionina auris* (d'Orbigny). X 75.
a, b, opposite sides; *c*, apertural view.
- FIGS. 5 *a-c*. *Frondicularia mexicana* Cushman, n. sp. X 50.
a, front view; *b*, section of young portion; *c*, section of adult with flatter or even concave faces.



RECENT LITERATURE ON THE FORAMINIFERA

Below are given some of the more recent works on the foraminifera that have come to hand.

ange, E.

Eine mittelpermische Fauna von Guguk Bulat. (Padangerberland, Sumatra).

(Verhandl. Geol.-Mijn. Gen. Ned. Kol. Geol. Ser., vol. 7, 1925, pp. 213-295, pls. 1-5, 10 text figs.) *The Hague.*

Pages 217-272 are given to the foraminifera with many photographic sections in the first four plates. In all, 79 species of foraminifera are dealt with of which 57 are described as new as well as 2 new genera, *Padangia* and *Pachyphloia*.

ilvestri, A.

Sur quelques foraminifères et pseudo-foraminifères de Sumatra.

(Verhandl. Geol.-Mijn. Gen. Ned. Kol. Geol. Ser., vol. 8, 1925, pp. 449-460, pls. 1-3.) *The Hague.*

Notes are given on a number of species of foraminifera from Sumatra. Twelve sections are given from photographs including new species of *Lacazina* and *Choffatella*.

obler, A.

Mesozoikum und Tertiär des Gumai-gebirges.

(Verhandl. Geol.-Mijn. Gen. Ned. Kol. Geol. Ser., vol. 8, 1925, pp. 521-535.) *The Hague.*

Notes are given on the occurrence of various foraminifera characteristic of different horizons in Sumatra.

an der Vlerk, I. M.

Lepidocyclina mediocolumnata nov. spec. de Pasir (Semborneo).

(Compte-Rendu quatrieme assemblee generale de la Soc. pal. suisse. Eclogae geologicae Helvetiae, vol. 19, No. 1, 1925, pp. 267-269, pl. 7.) *Basle.*

This new species from Borneo is described in detail. Excellent figures are given of this and of *L. formosa* Schlumberger.

Van der Vlerk, I. M.

De Verspreiding van het Foraminiferen-Geslacht *Lepidocyclina* en Haar Beteekenis Voor de Palaeogeographie.

(Handel. Derde Nederl. Indisch Nat. Congres., 1924 (1925),
9 pages.) *Buitenzorg.*

Many general notes are given on the occurrence of *Lepidocyclina* and related forms in relation both to time and horizontal distribution. World distribution is summarized.

Nuttall, W. L. F.

The Stratigraphy of the Laki Series (Lower Eocene) of parts of Sind and Baluchistan (India); with a Description of the Larger Foraminifera contained in those Beds.

(Quart. Journ. Geol. Soc., vol. 81, 1925, pp. 417-453, pls. 23-27, 5 text figures.) *London.*

A short outline of the geological history of the region is followed by descriptions of some of the foraminifera as well as a comparison of the Indian fauna with that of southern Europe. Fourteen species are given in detail. Two new species and a new variety are described, as well as a new genus *Opertorbitolites*. The plates are made up from excellent photographs of sections and exteriors.

Martinotti, A.

Osservazioni sulla *Nodosaria annulata* Rs. e sulla *Nodosaria paronai* Derv.

(Riv. Sci. Nat. "Natura," vol. 16, 1925, pp. 79-83, 6 figures in text.) *Pavia.*

Excellent figures are given with sections of these two species from the Pliocene and Miocene of Italy.

Chapman, F.

Foraminifera and Oil.

(The Melbourne [Australia] "Argus," Sept. 19, 1925.)

This newspaper article connects very definitely the occurrence of foraminifera and oil in many parts of the world giving examples where the tests of fossil foraminifera as far back as the Carboniferous are lined with such material.

Nuttall, W. L. F.

Two Species of Eocene Foraminifera from India, *Alveolina elliptica* and *Dictyoconoides cooki*.

(Ann. Mag. Nat. Hist., ser. 9, vol. 16, Oct. 1925, pp. 378-388, pls. 20, 21.) *London.*

Very full descriptions and excellent figures are given of these forms from the Eocene.

eede, J. W. and Kniker, H. T.

Species of the Genus Schwagerina and Their Stratigraphic Significance.

(Bull. 2433, Univ. Texas, Sept. 1, 1924, pp. 1-98, pls. 1-9, with map.) *Austin.*

This paper is a monographic treatment of all the previously known species of the genus and some new ones with their detailed descriptions, illustrated by figures of the exteriors as well as various sections. Much interesting information is included on the structure, evolution of the group, and the world distribution.

Iwano, Y.

A Brief Critical Revision of the Fusulina—Species Recently Described, with Additional Studies of Japanese Fusulinae.

(Journ. Geol. Soc. Tokyo, vol. 32, May, 1925, pp. 19-27, pls. 9, 10.) *Tokyo.*

This paper is as its title indicates a revision of recently described species from the Orient. Two plates from photographed sections are included.

J. A. C.

